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DNAPL Investigation Status Summary

Detrex Site – Ashtabula, Ohio

APRIL 2012

Prepared by
URS Corp.
Cleveland Office

Topics

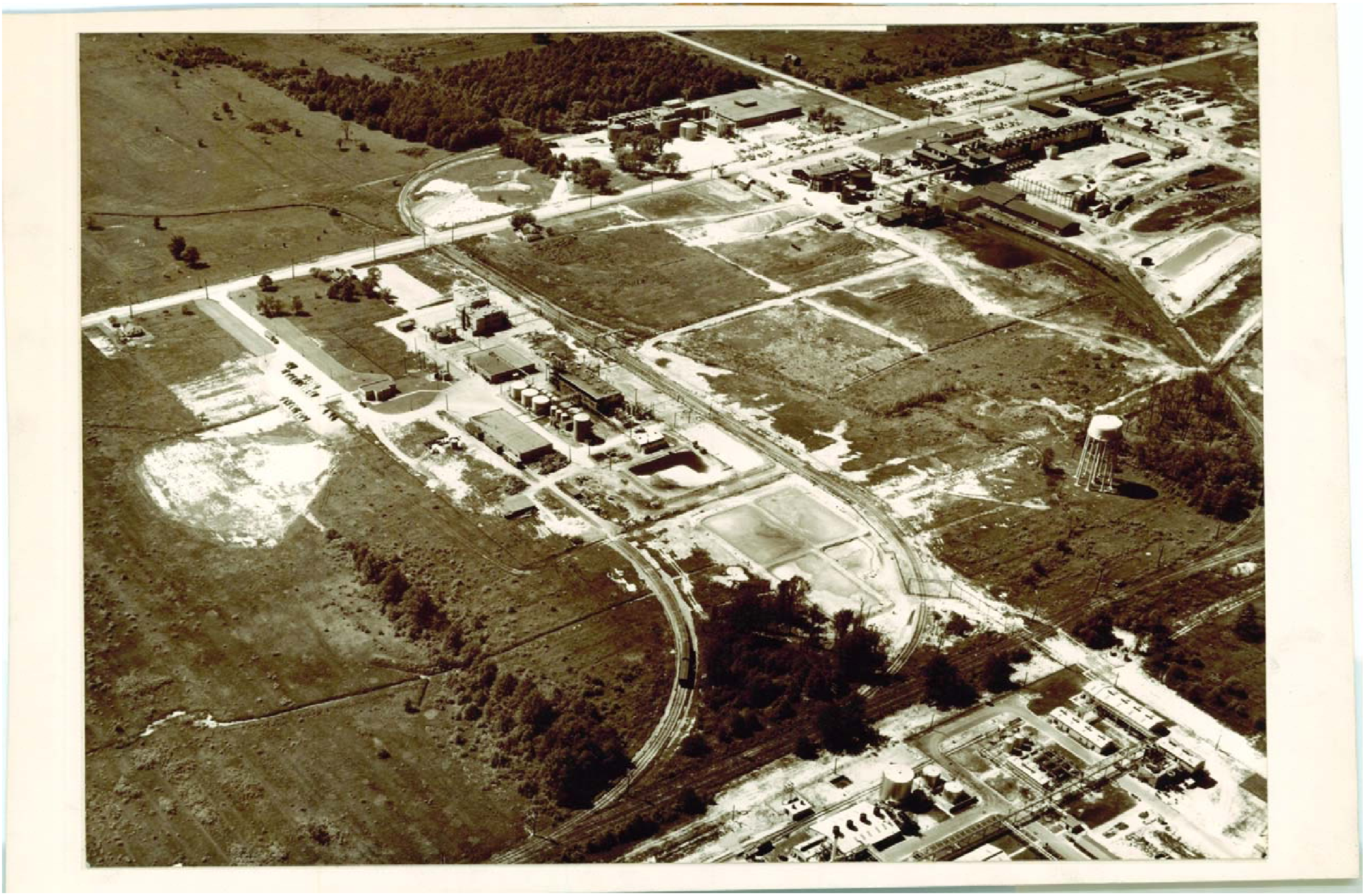
- Overview of Work Plan
- Work Completed
- MIP and Soil Boring Data Summary
- Updated Conceptual Site Model
- Work Plan Discussion
- Path Forward

OVERVIEW OF WORK PLAN

Overview of Work Plan Scope

- Membrane Interface Probe (MIP) Investigation
- Soil Borings
- Surveying
- Test Trenches (Former Lagoon Area)
- MW and PZ Well Inspections
- Initial DNAPL Recovery Testing
- Data Evaluation
- Conceptual Site Model (CSM) Update
- Detrex/USEPA Technical Meeting
- Recovery Well Design & Testing
- Data Evaluation & Reporting

Historical Aerial Photo / Base Map (circa 1955-1960)



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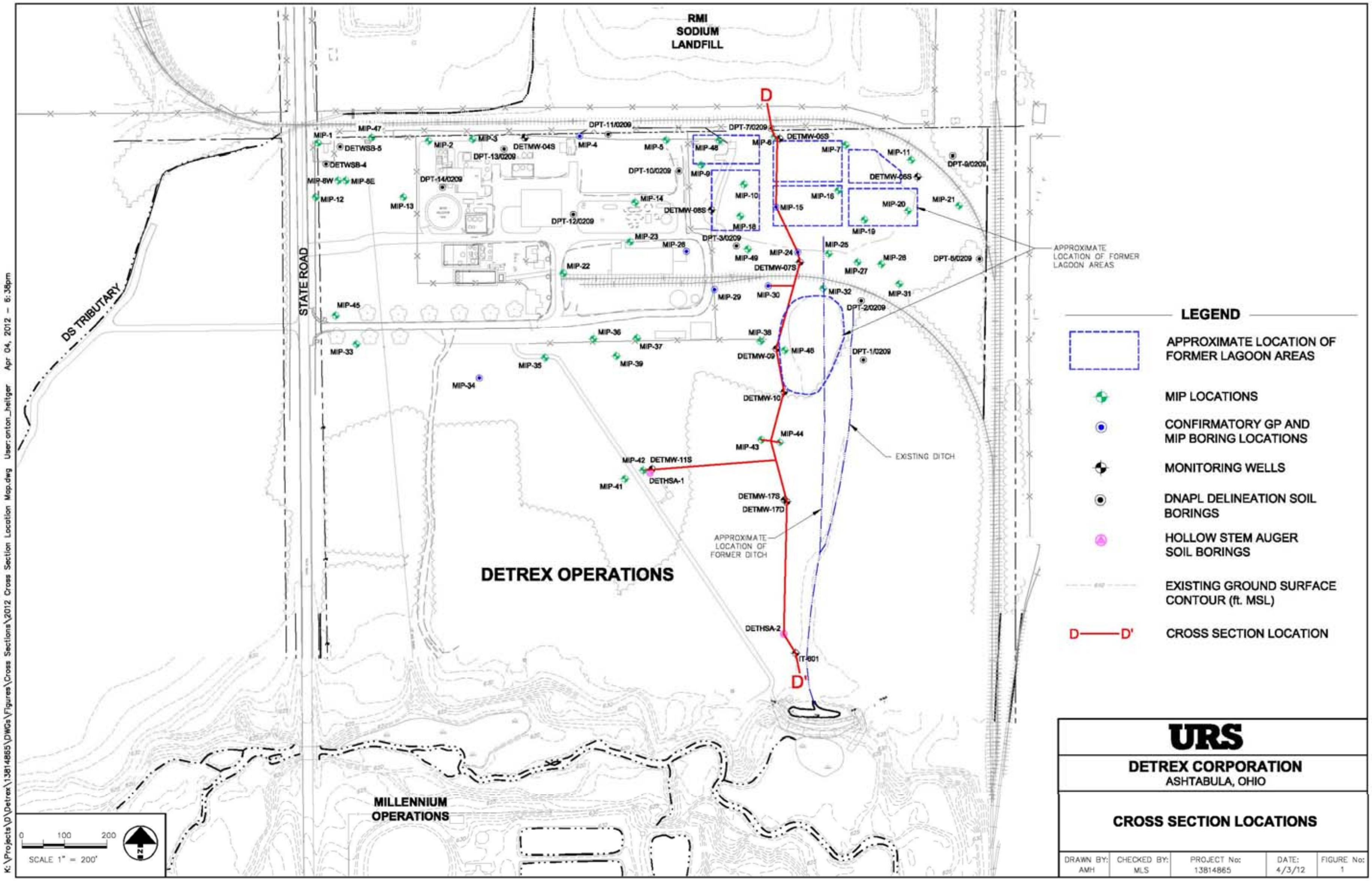

WORK COMPLETED

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Work Completed

- Membrane Interface Probe (MIP) Investigation
  - Forty-seven (47) MIP locations
- Soil Borings
  - Seven (7) SB locations, approximately 20-feet deep
- Surveying of MIP Locations
- MW and PZ Well Inspections
- Preliminary DNAPL Assessment in Wells (MW 05, 06, 07, and 08)
- MIP Data Evaluation
- Conceptual Site Model (CSM) Update

MIP AND SOIL BORING DATA SUMMARY

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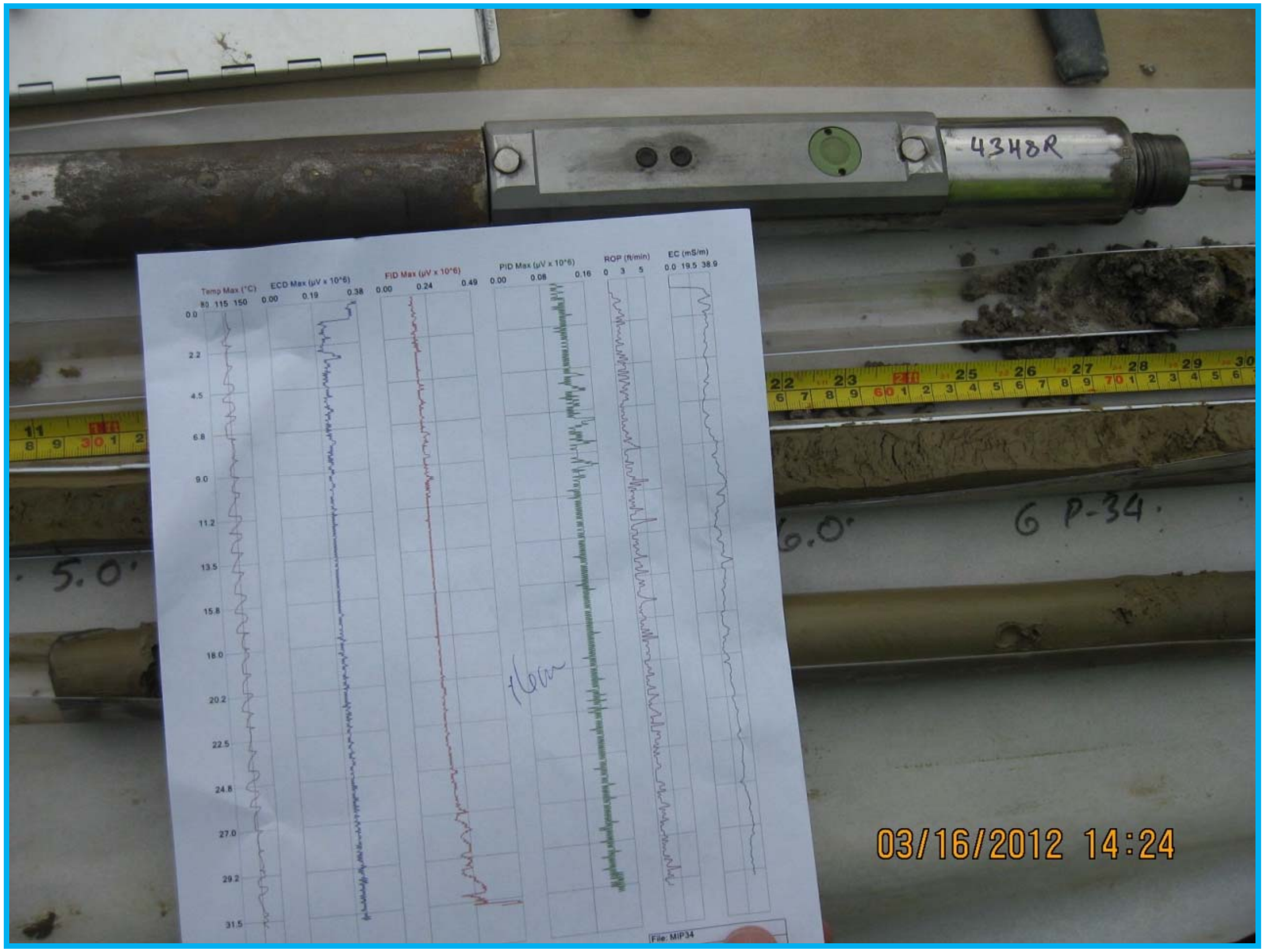
MIP Data Collection Process

- Sensor on side of Geoprobe
- Probe heats soil to approximately 100-120 degrees Celsius
- Vapor phase collected through Teflon, stainless steel membrane on probe
- Transferred to GC in trailer
- Samples collected at 1.0-ft intervals
- Temperature, rate of penetration, ECD, FID, PID, and conductivity
- Due to presence of CVOCs present, ECD is not usable
- PID response indicates presence of elevated concentrations of CVOC in soil / possible NAPL / water saturated sheen

Membrane Interface Probe



MIP Overview

- Three areas of site investigated
  - Former Lagoon Area (NE portion)
  - Within Plant Area (North-Central portion)
  - Outside Plant Area(West and South)

- More than 29,530 data points collected over 10 acres

MIP OVERVIEW
FORMER LAGOON AREA

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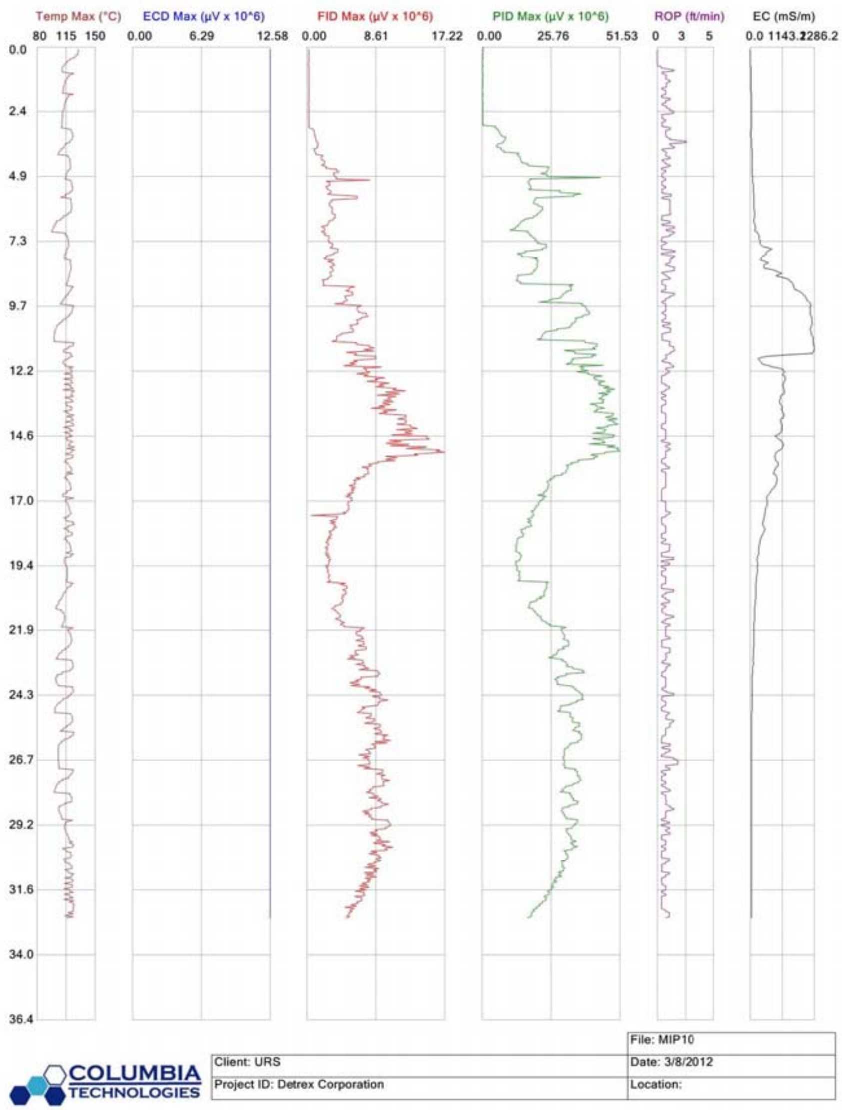
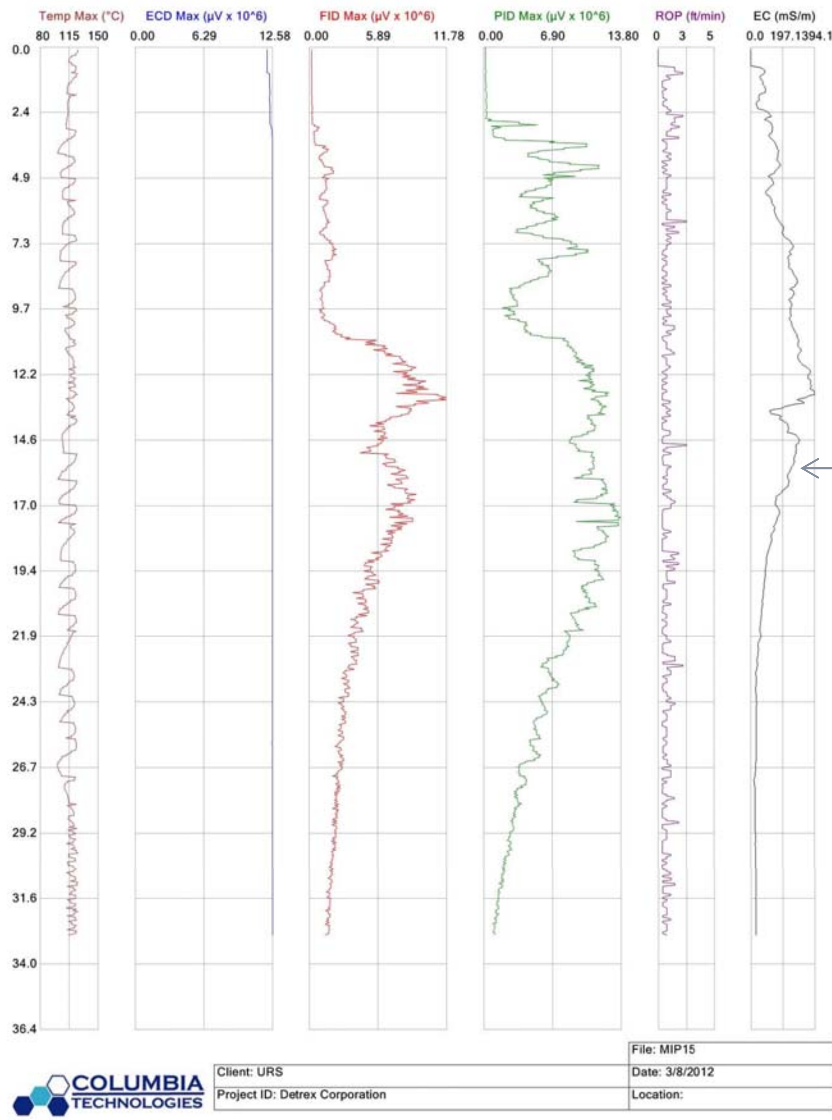


MIP – 10 Log

(inside lagoon area)



MIP – 15 Log

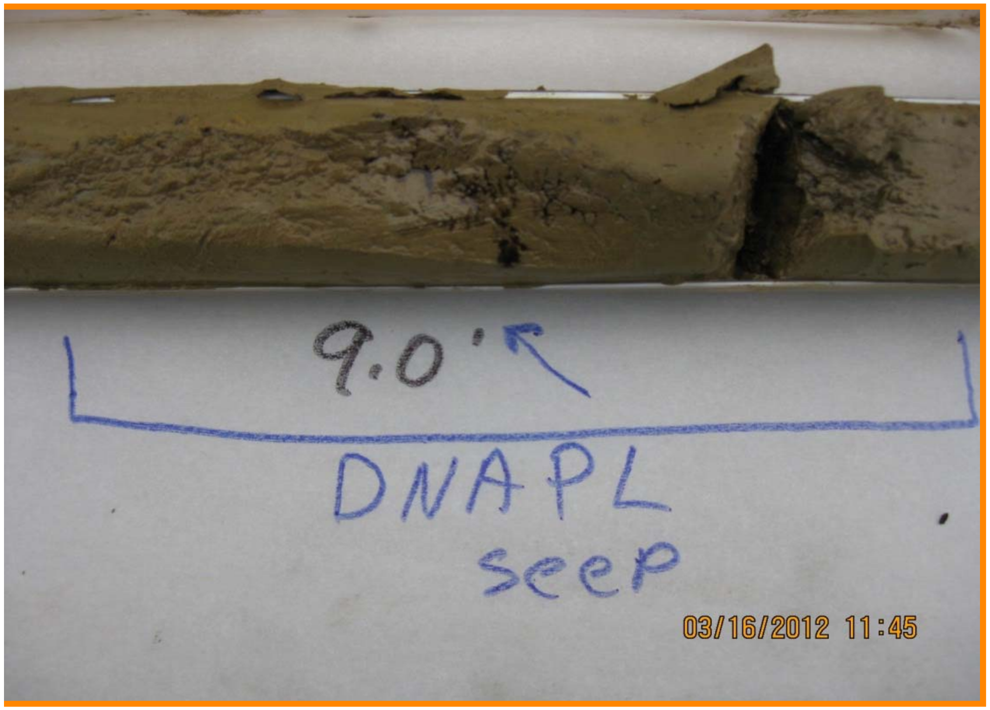
(inside lagoon area)

Fill to 16.0 ft

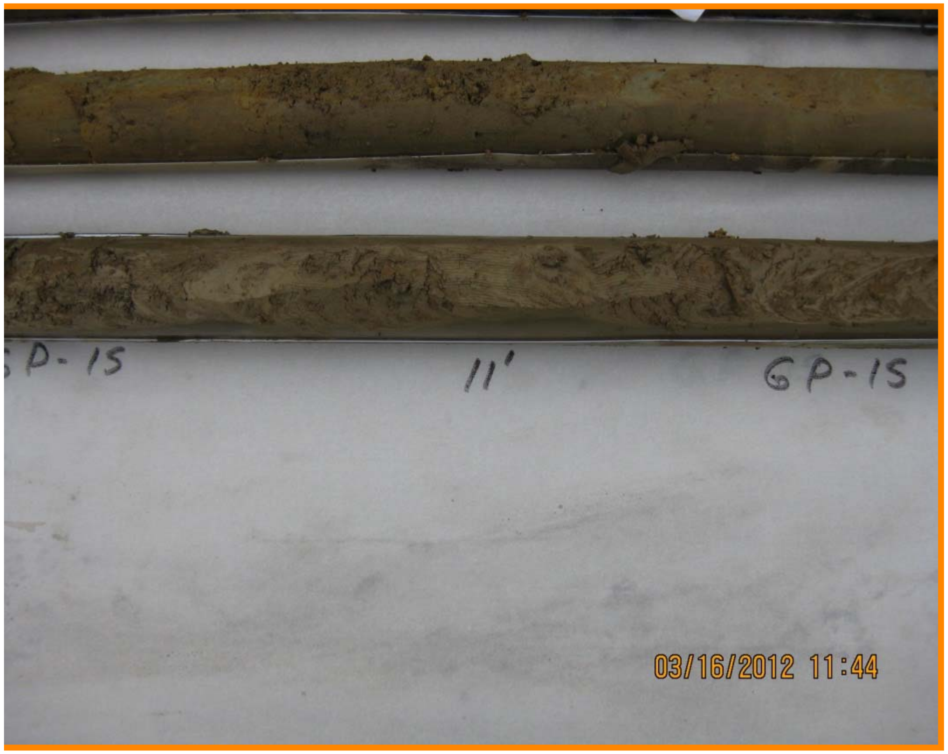
Gray silts / clays

GP-15 Photos

GP-15 Photos



GP-15 Photos



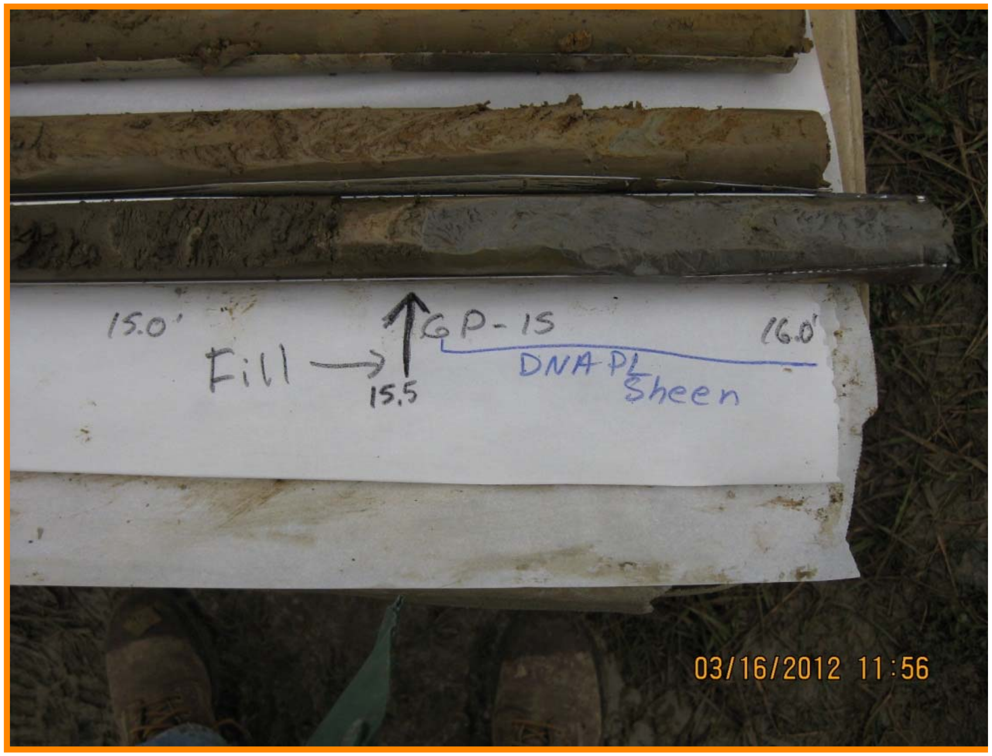
GP-15 Photos


12.0'
GP-15
13.0'
Fill
03/16/2012 11:56


13.0'
GP-15
14.0
Fill
03/16/2012 11:56

GP-15 Photos


14.0'
GP-15
15.0'
Fil
03/16/2012 11:56


15.0'
Fill
15.5
GP-15
16.0'
DNAPL
Sheen
03/16/2012 11:56

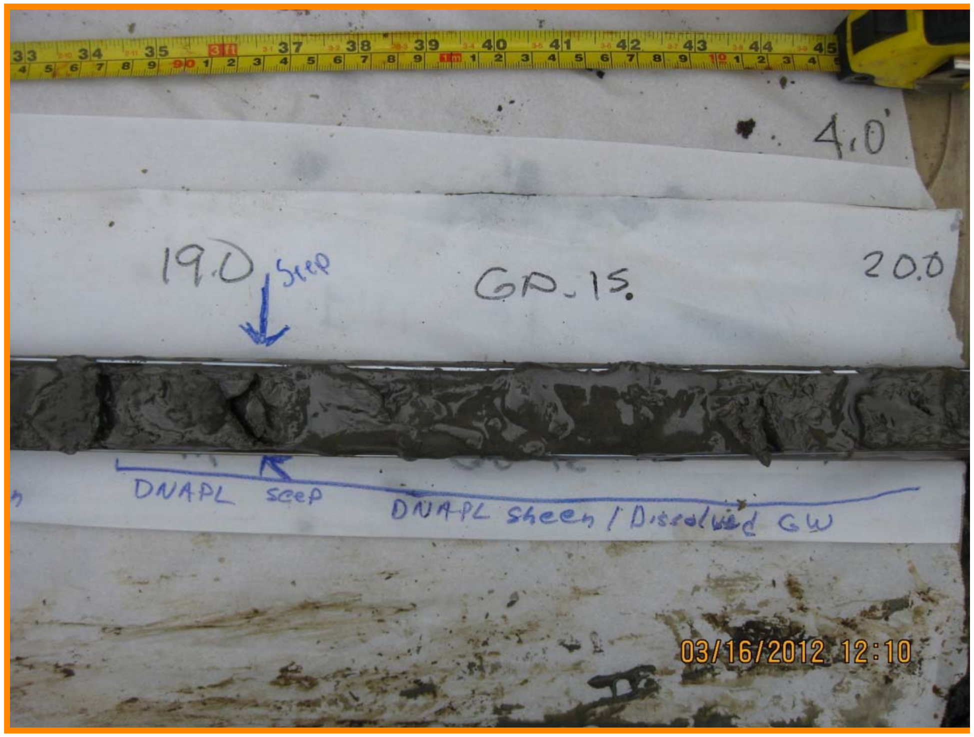
GP-15 Photos

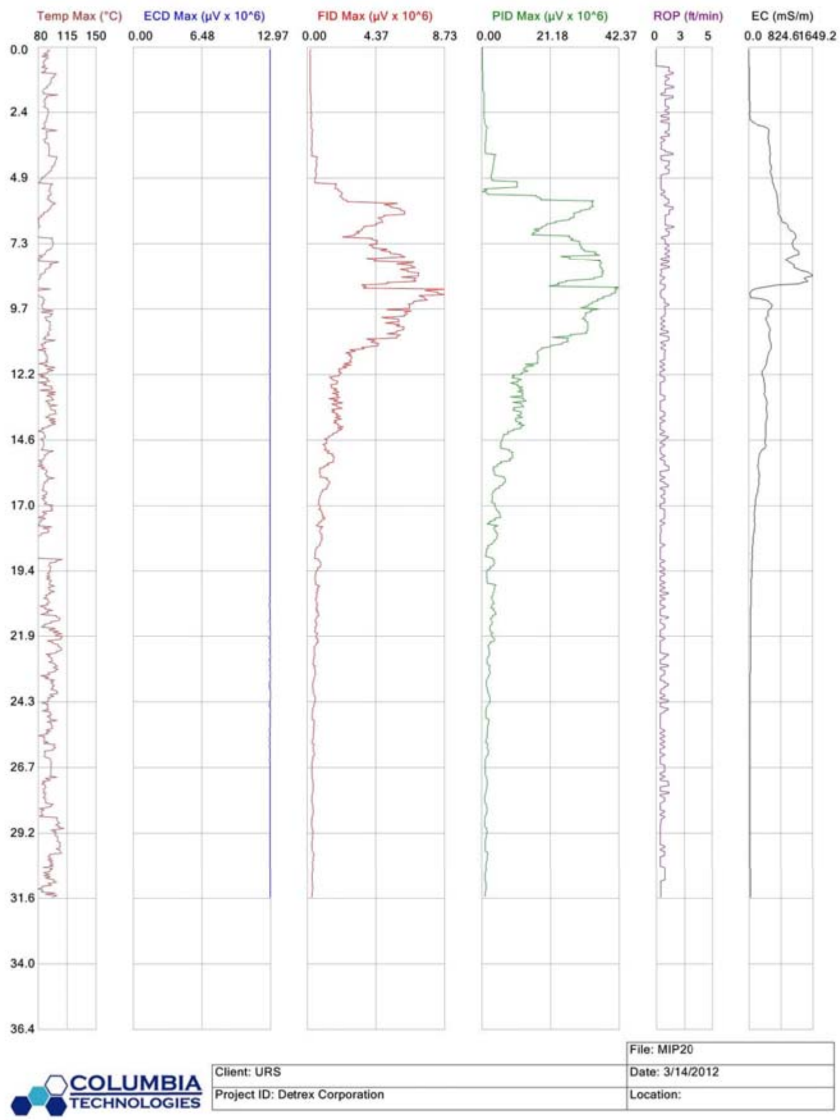

16.0'
GP-15
17.0'
03/16/2012 12:09


17.0'
GP-15
18.0
DNAPL Sheen
03/16/2012 12:09

GP-15 Photos

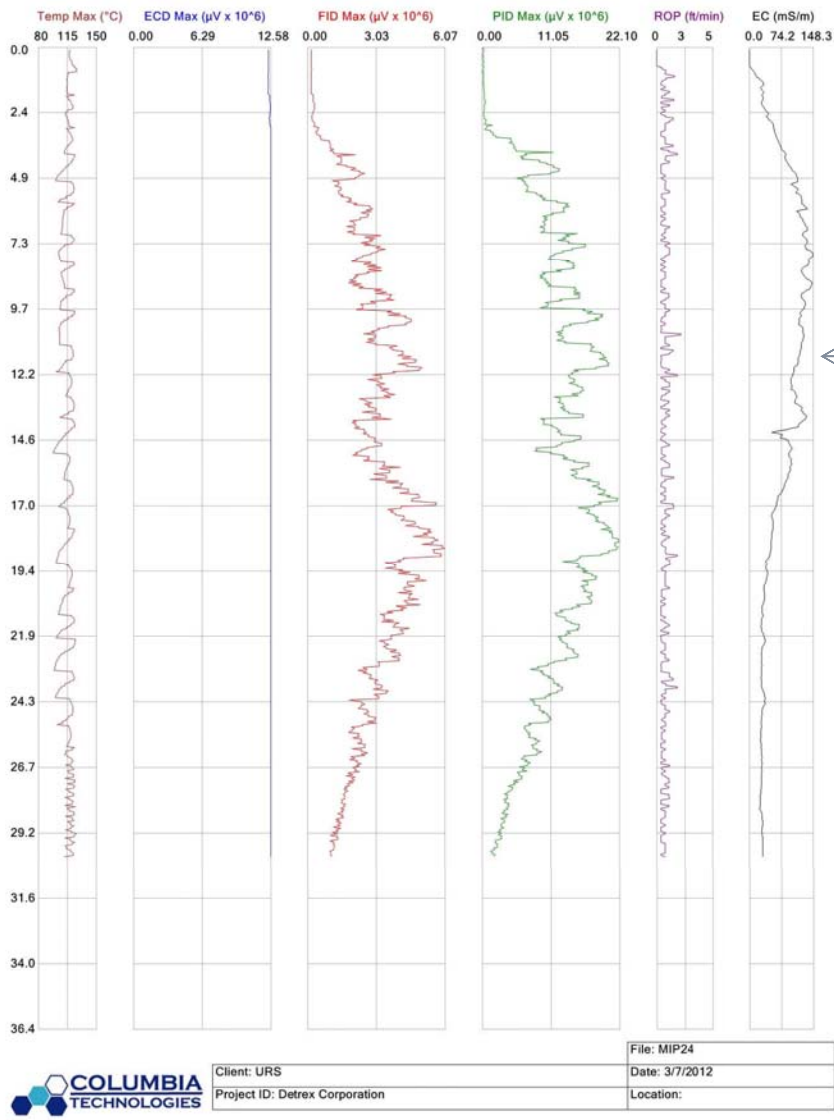

18.0
GP-15
19.0
seep
DNAPL sheen
DNAPL seep
03/16/2012 12:09


4.0'
19.0
seep
GP-15
20.0
DNAPL seep
DNAPL sheen / Dissolved GW
03/16/2012 12:10



MIP – 20 Log

(inside lagoon area)



MIP – 24 Log

(natural soils, south of lagoon)

Brown clay soils

Gray clay

GP-24 Photos

GP-24 Photos

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GP-24 Photos

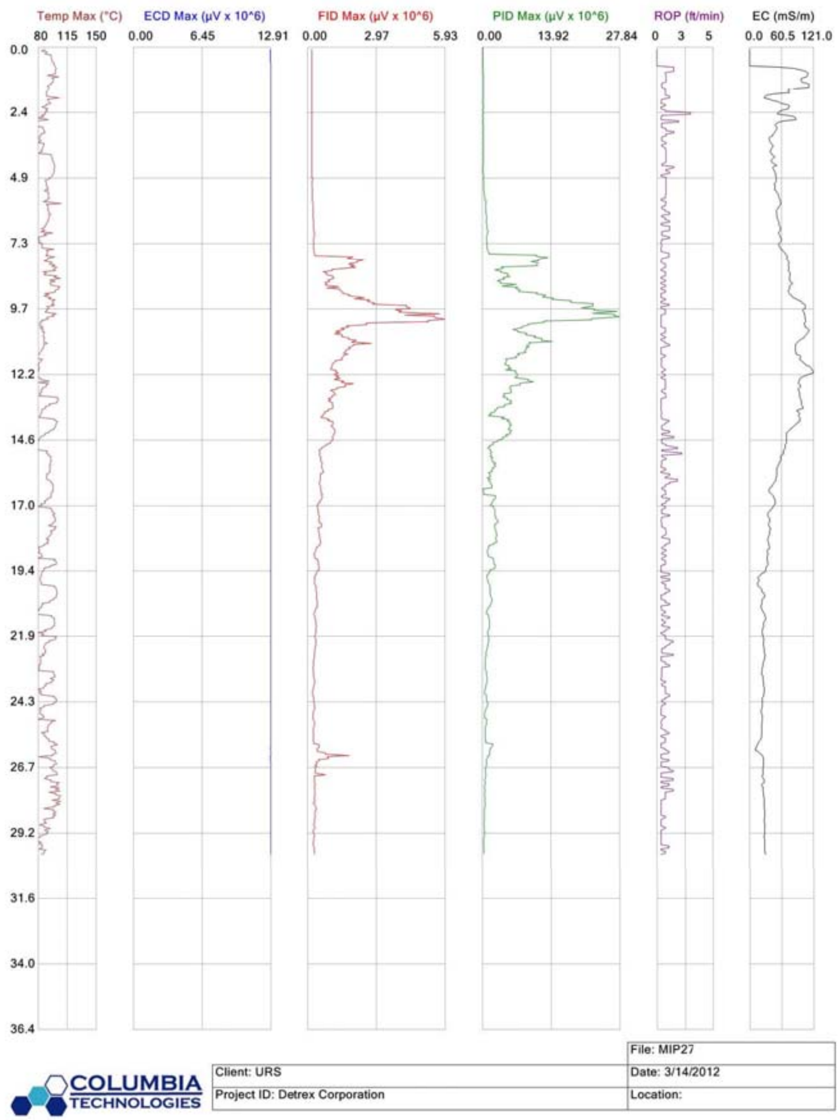
GP-24 Photos

GP-24 Photos


10.0
DNAPL
seeps
03/16/2012 11:10

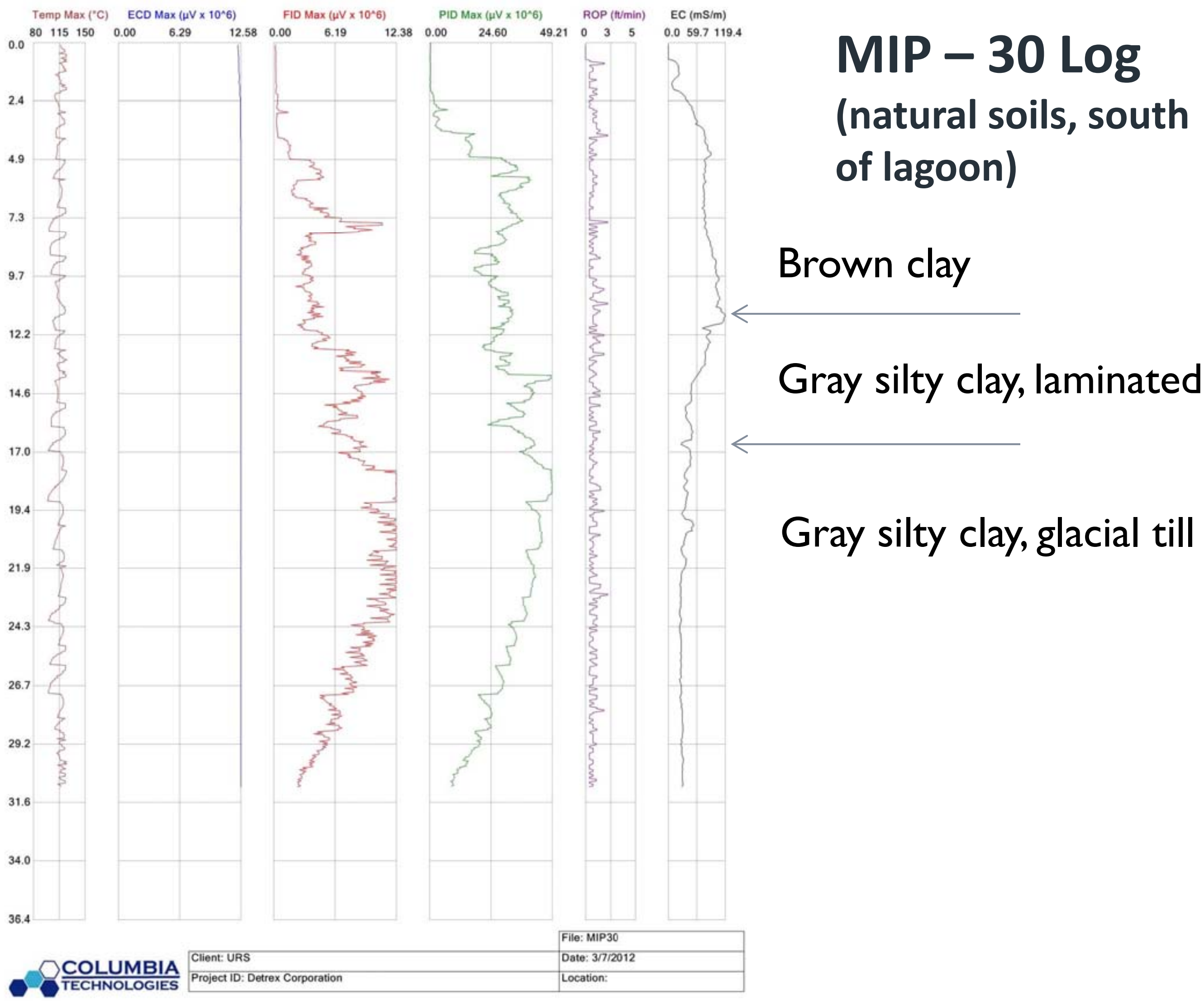

10.0
DNAPL
seeps
03/16/2012 11:11

GP-24 Photos



MIP – 27 Log

(natural soils, east of lagoon)

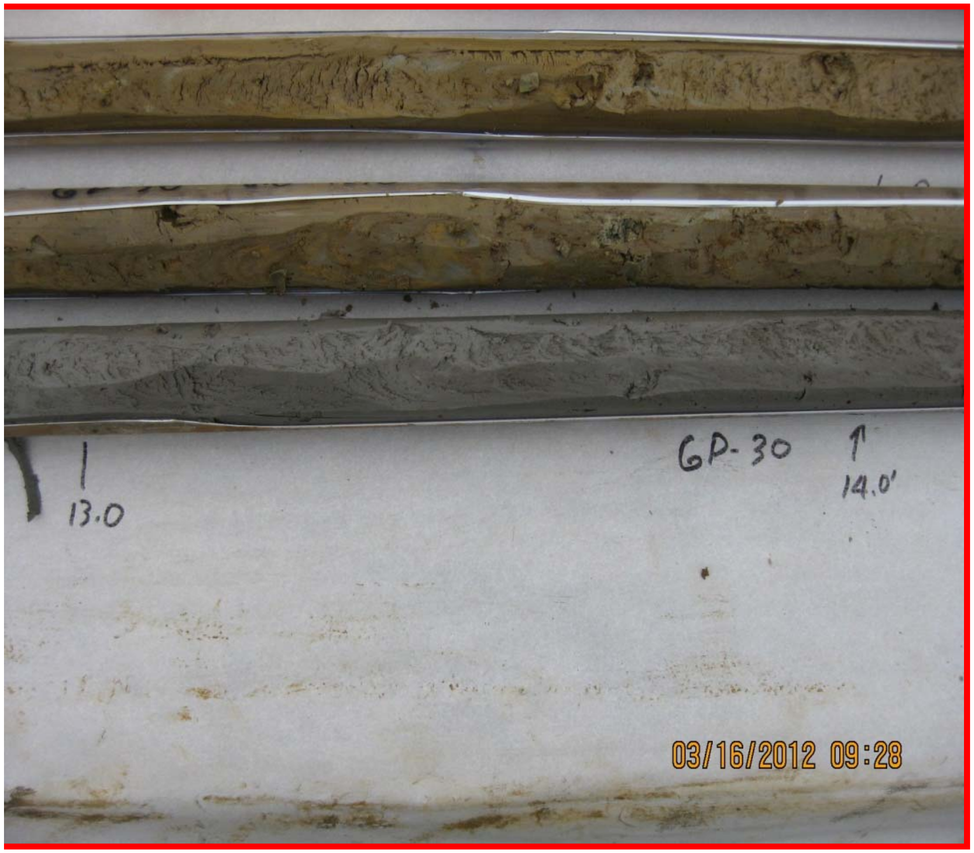


MIP – 30 Log

(natural soils, south of lagoon)

GP-30 Photos

GP-30 Photos



GP-30 Photos


15.0' GP-30
GP-30
16'
03/16/2012 09:28


16.0
GP-30
17.0
GP-30
03/16/2012 10:39

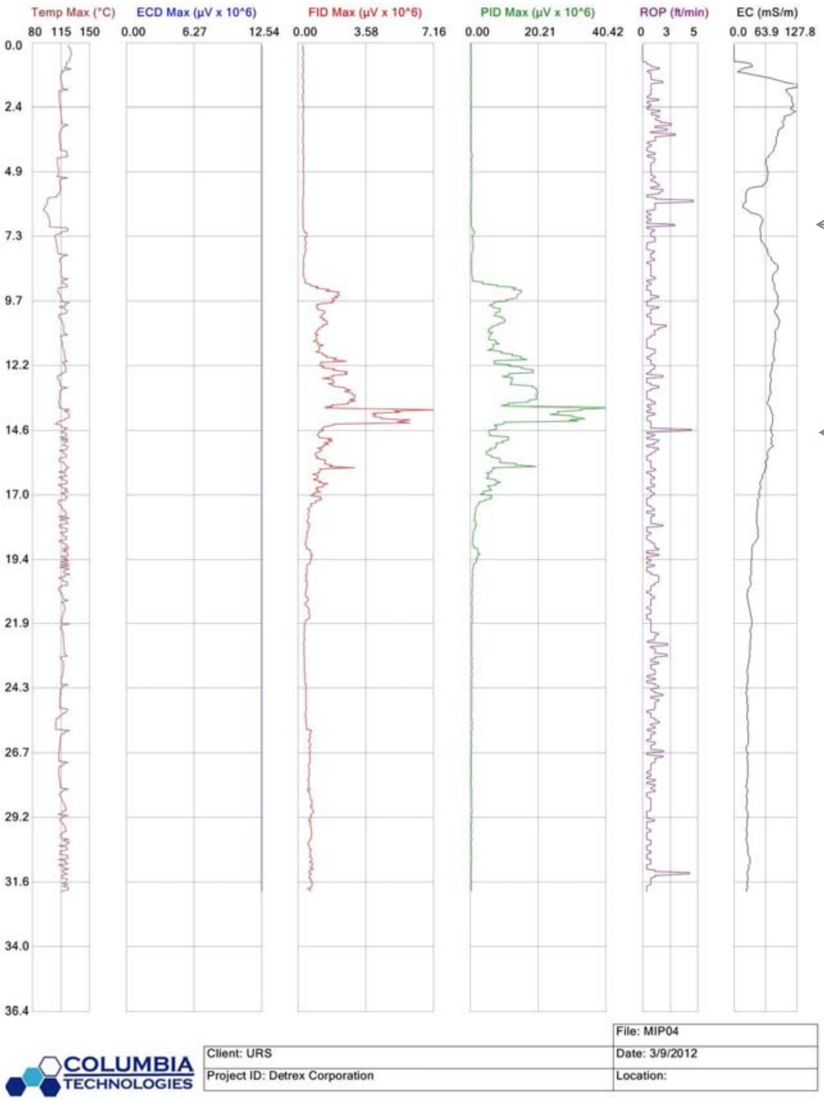
GP-30 Photos

GP-30 Photo

MIP OVERVIEW WITHIN PLANT AREA

MIP – 04 Log

(fill, natural soils, north plant area)



Fill

Brown clays, laminated

Gray silty clay, laminated

GP-04 Photos


SemperGuard Nitrile
Powder-Free
size L
GP-4
4.0
GP-4
GP-4
8.0
KOBALT
03/16/2012 13:41


8.0
GP-4
9.0'
03/16/2012 13:44

GP-04 Photos


9.0'
GP-4
10.0'
Slight Shee
03/16/2012 13:45

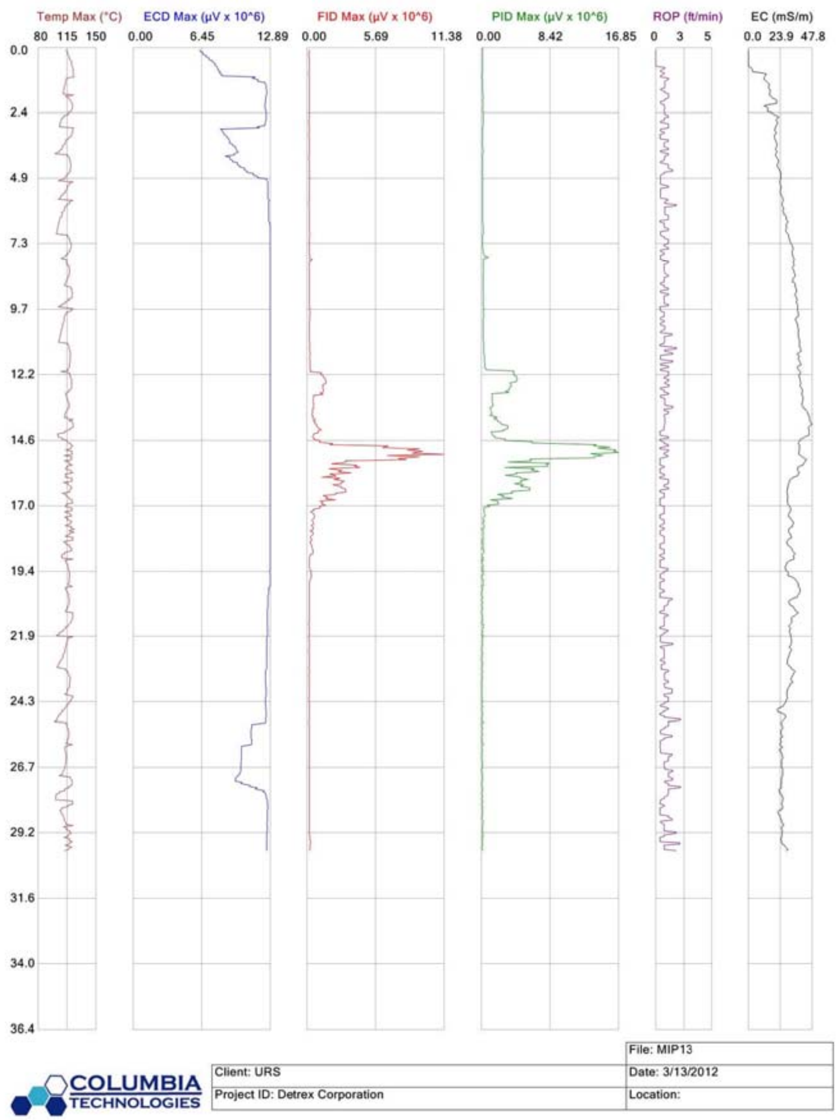

10.0'
Slight Sheen
GP-4
11.0'
03/16/2012 13:45

GP-04 Photos

GP-04 Photos

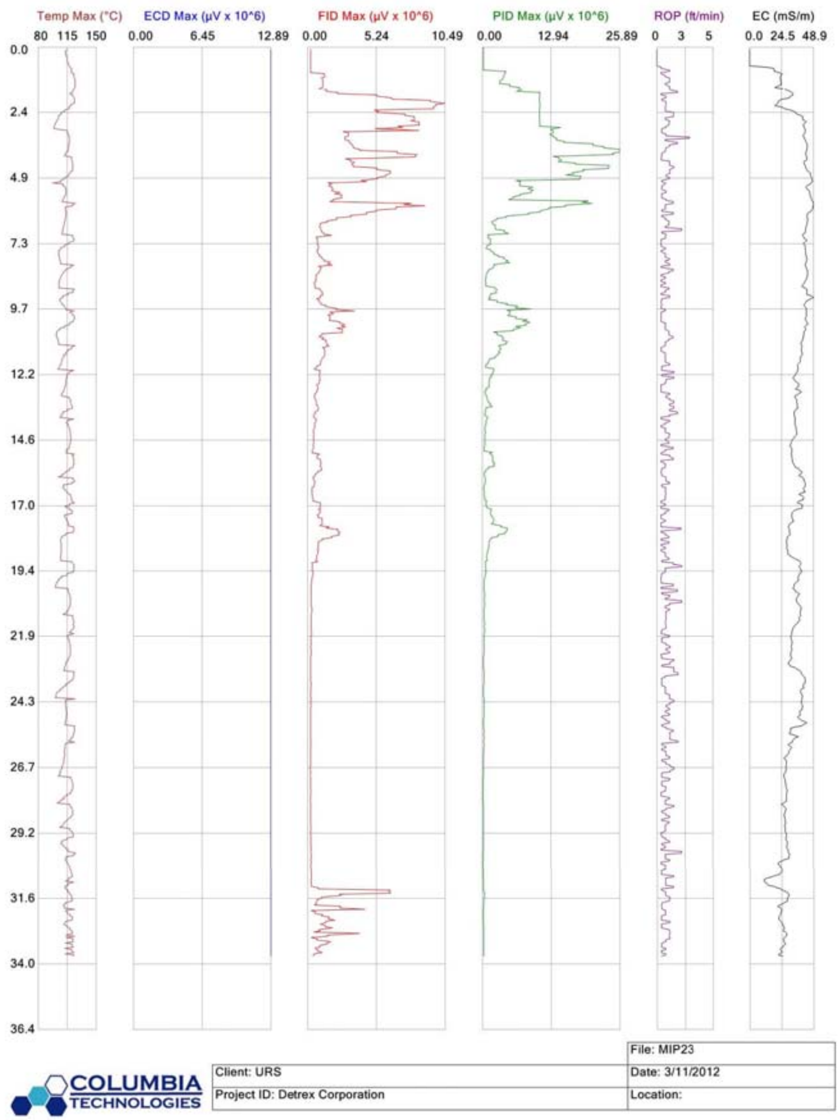
GP-04 Photos

URS



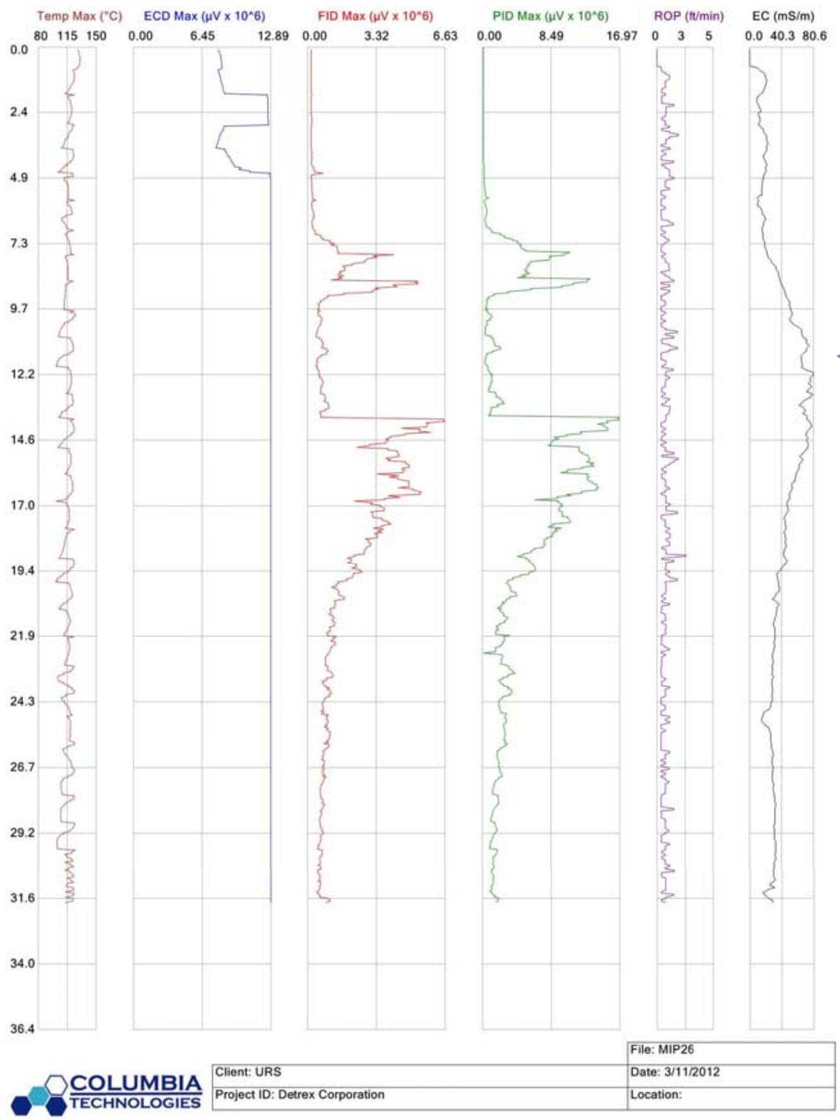
MIP – 13 Log

(natural soil, west of plant)



MIP – 23 Log

(natural soil, plant)



MIP – 26 Log

(natural soil, plant)

Brown clay

Gray silty clay

GP-26 Photos


GS
GP-26
5.0'
DNAPL Sheen GP-26
6.0'
03/16/2012 13:03


GP-26
4.0'
6.0'
GP-26
8.0'
03/16/2012 13:03

GP-26 Photos


8.0
GP-26
~9.5
DNAPL Sheen / Dissolved
03/16/2012 13:13


~9.5
GP-26
12'
03/16/2012 13:13

GP-26 Photos


12.0'
GP-26
13.0
GP-
DNAPL
Seep
03/16/2012 13:20


14.0'
GP-26
15.0'
03/16/2012 13:21

GP-26 Photo

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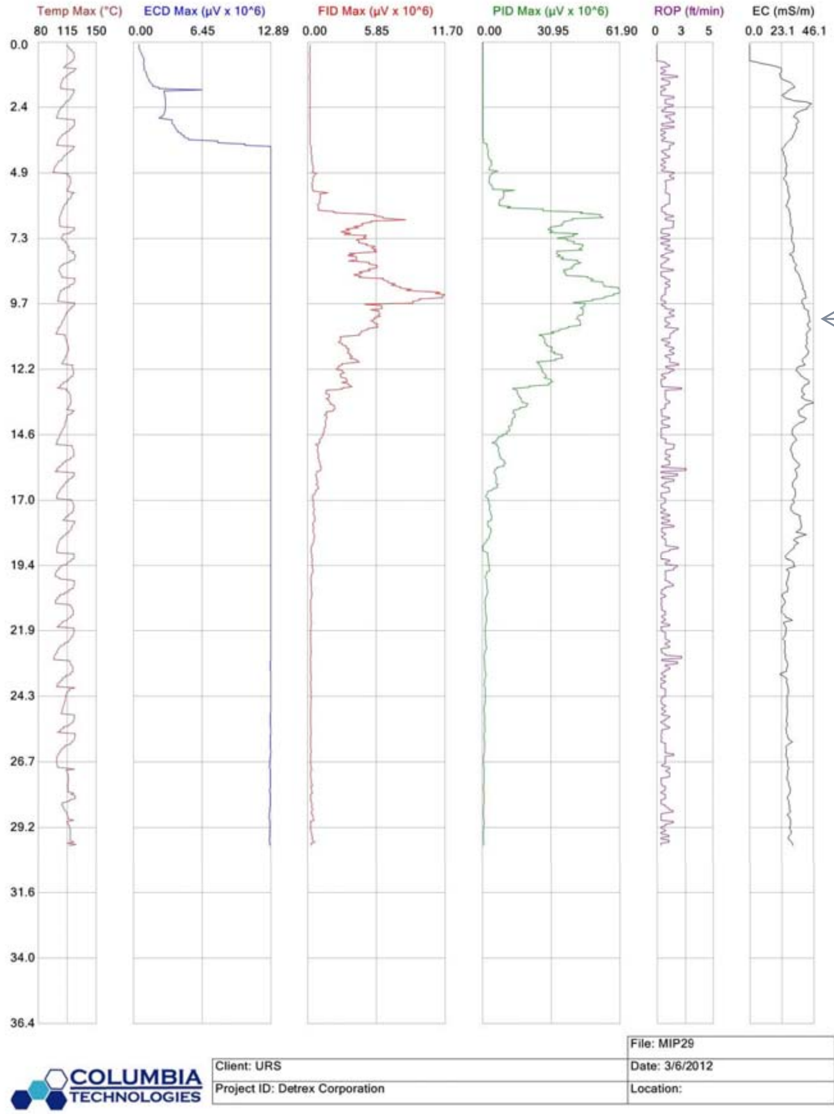
MIP – 29 Log

(natural soils, plant)

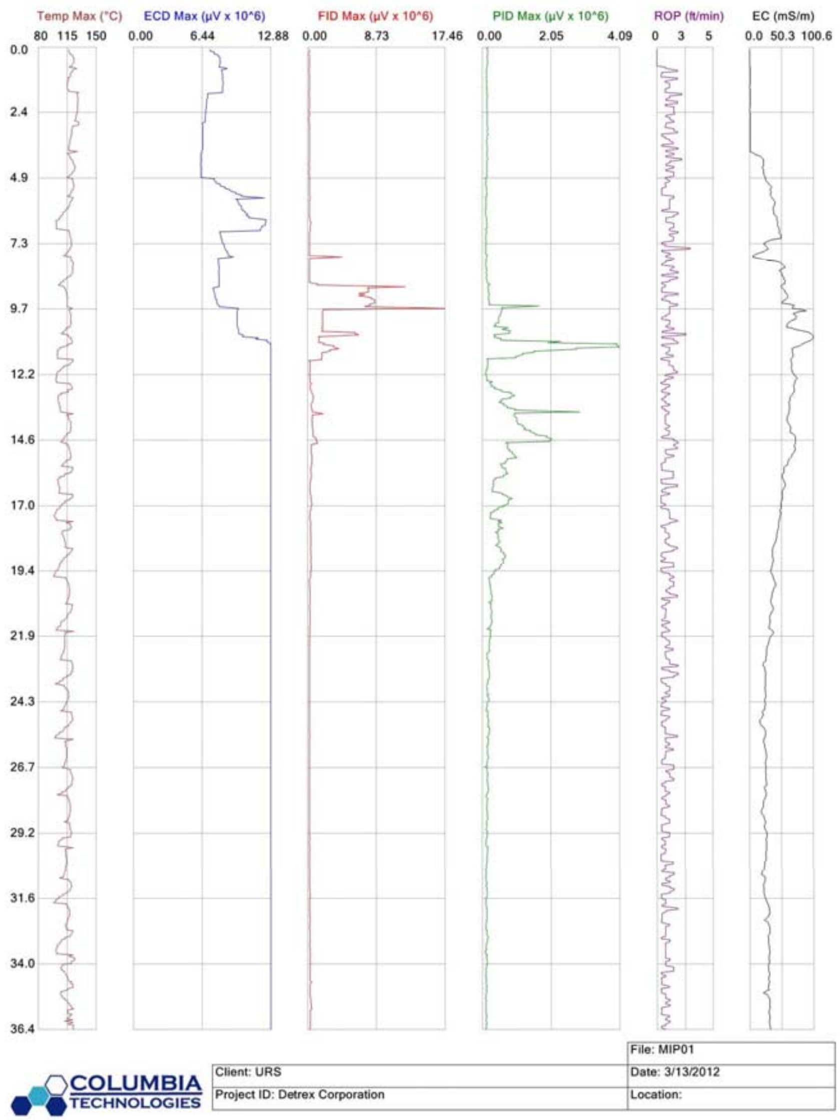


Brown clay

Gray silty clay

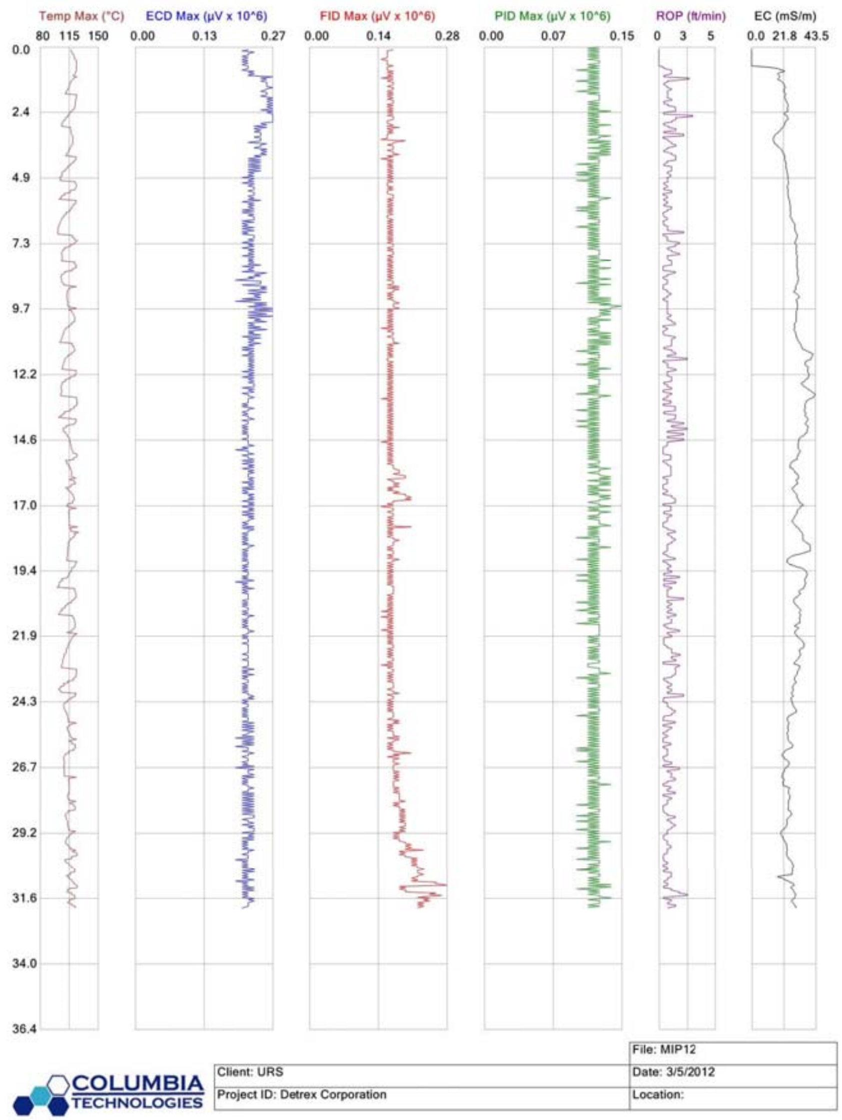
GP-29 Photo

MIP OVERVIEW
OUTSIDE PLANT AREA



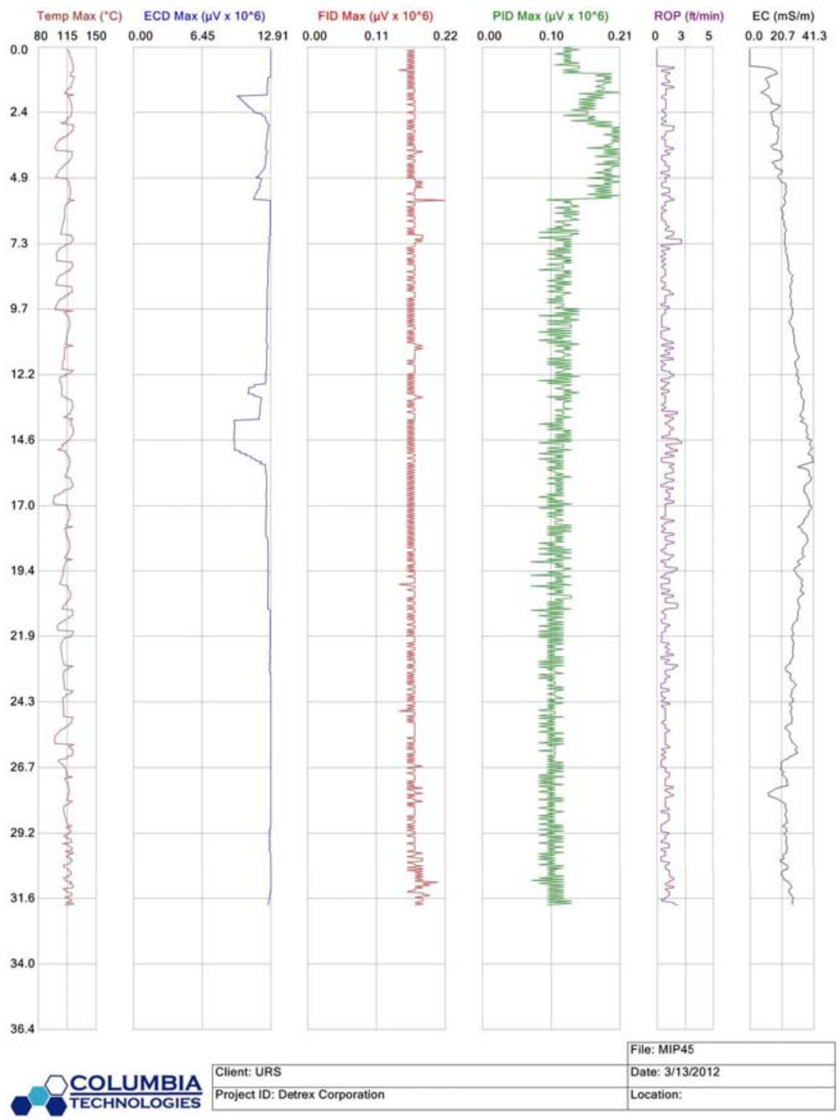
MIP – 01 Log

(natural soils, northwest near 14-inch drain line)



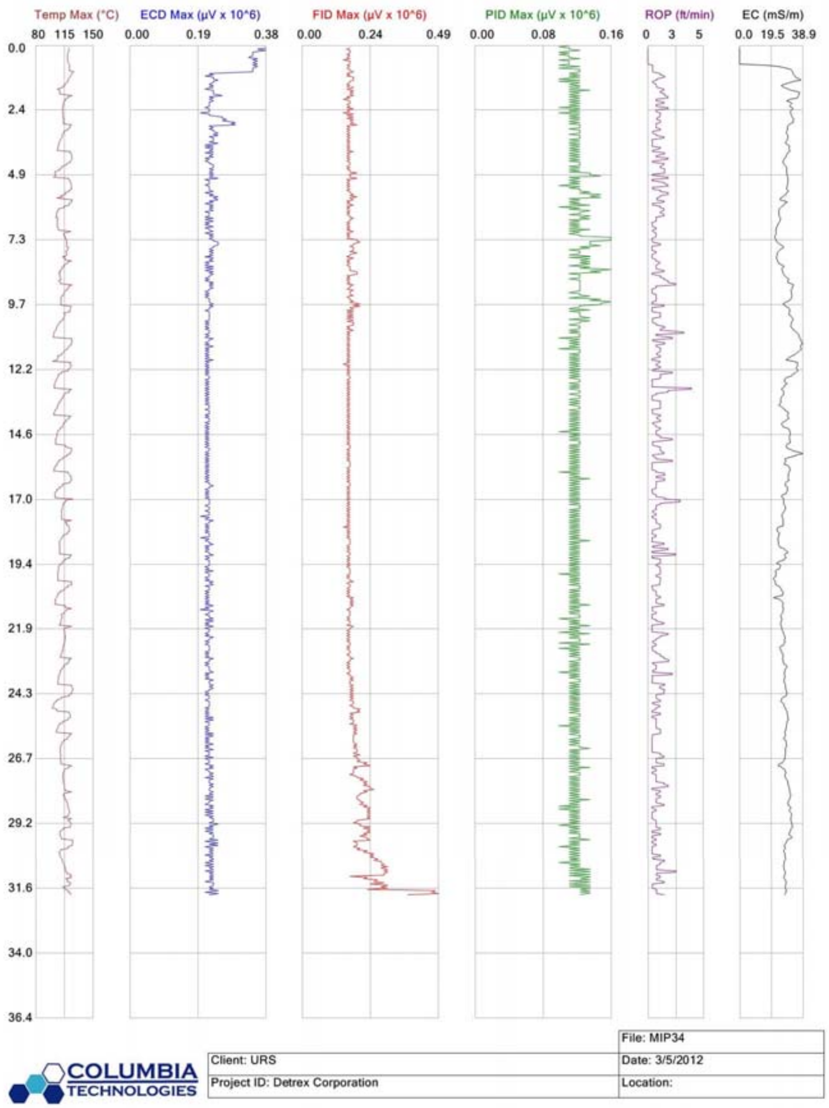
MIP – 12 Log

(west side, slurry wall)



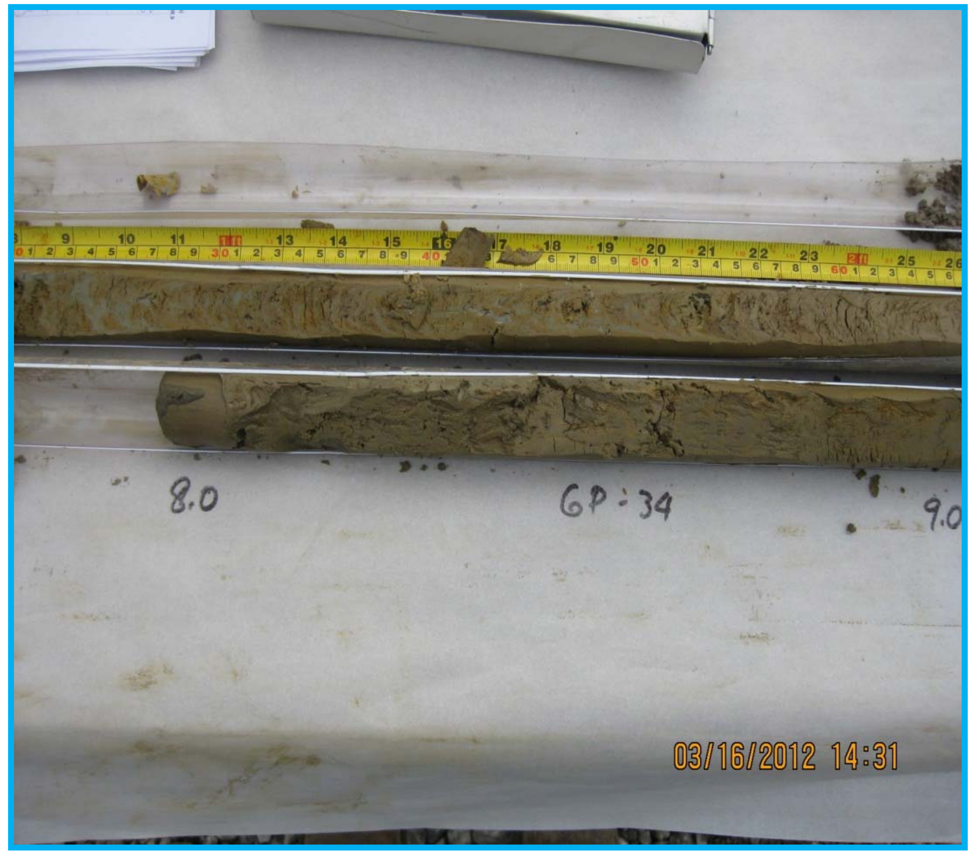
MIP – 45 Log

(west side entrance to facility)



MIP – 34 Log
(south side, parking)

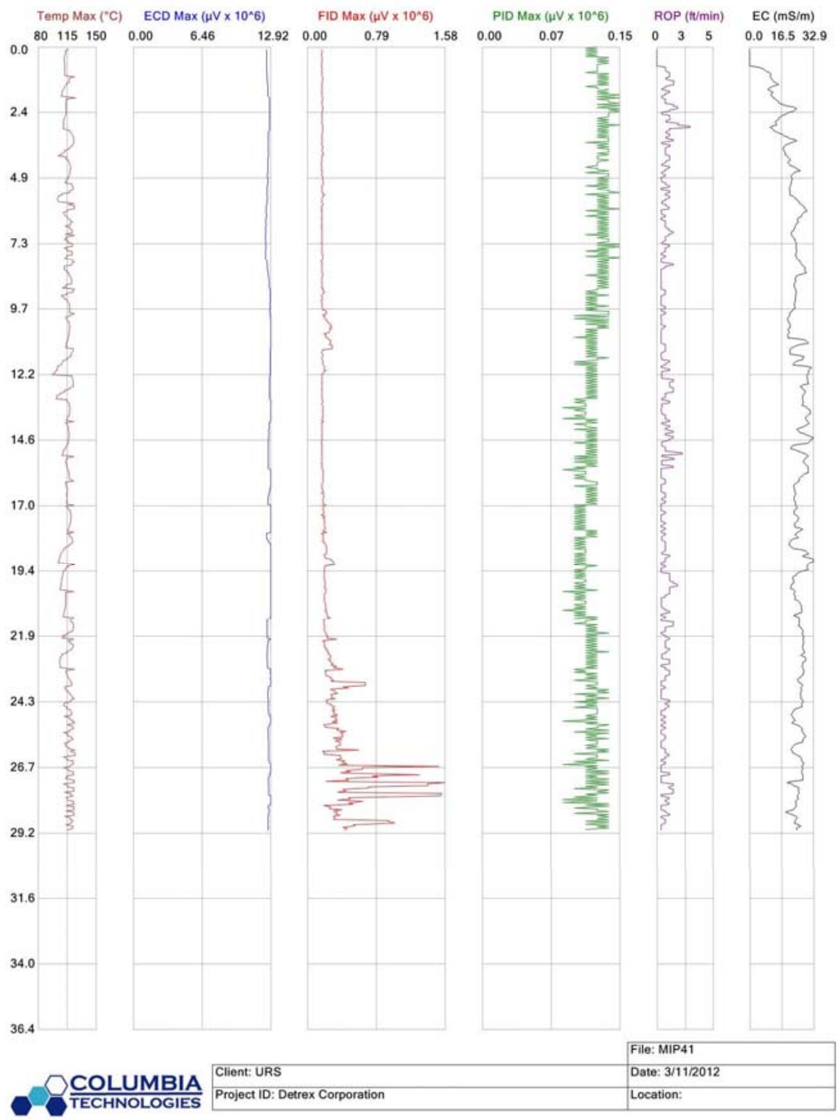
GP-34 Photos



GP-34 Photos


GS
GP-34
9.0'
GP-34
03/16/2012 14:31


GS
GP-34
4.0
GP-34
10.0'
KOBALT
03/16/2012 14:32

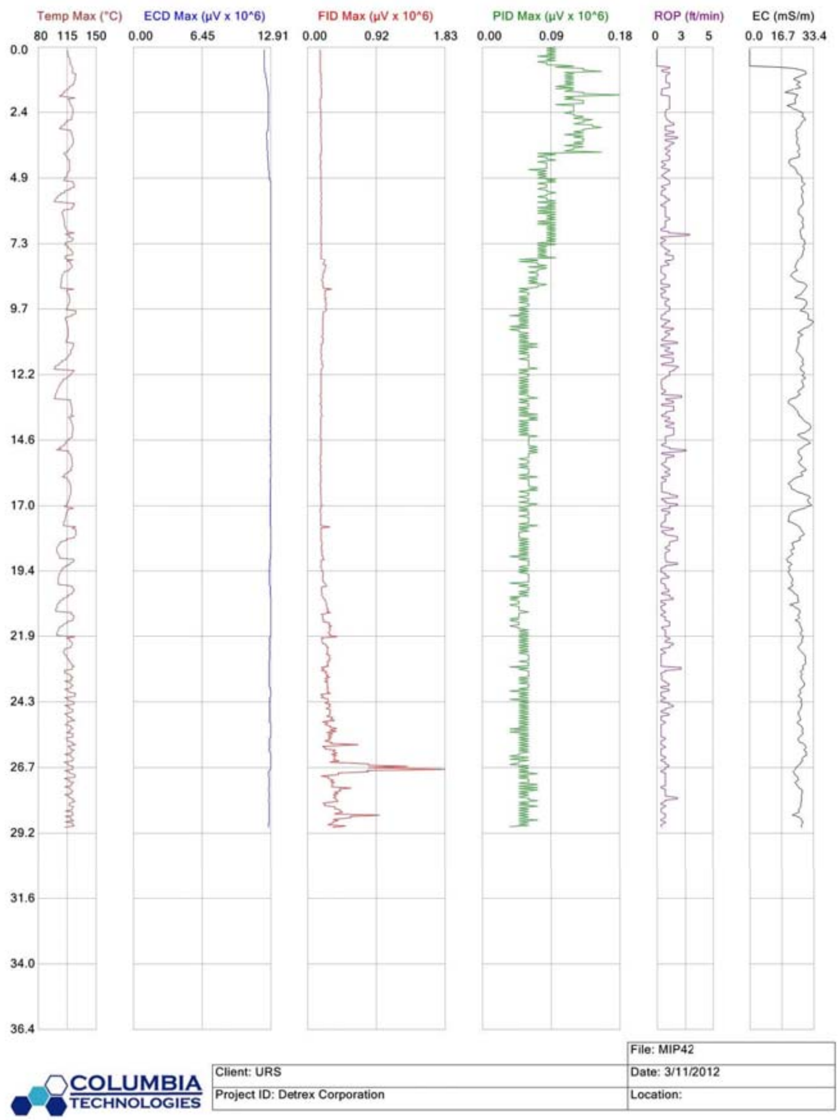


MIP – 41 Log

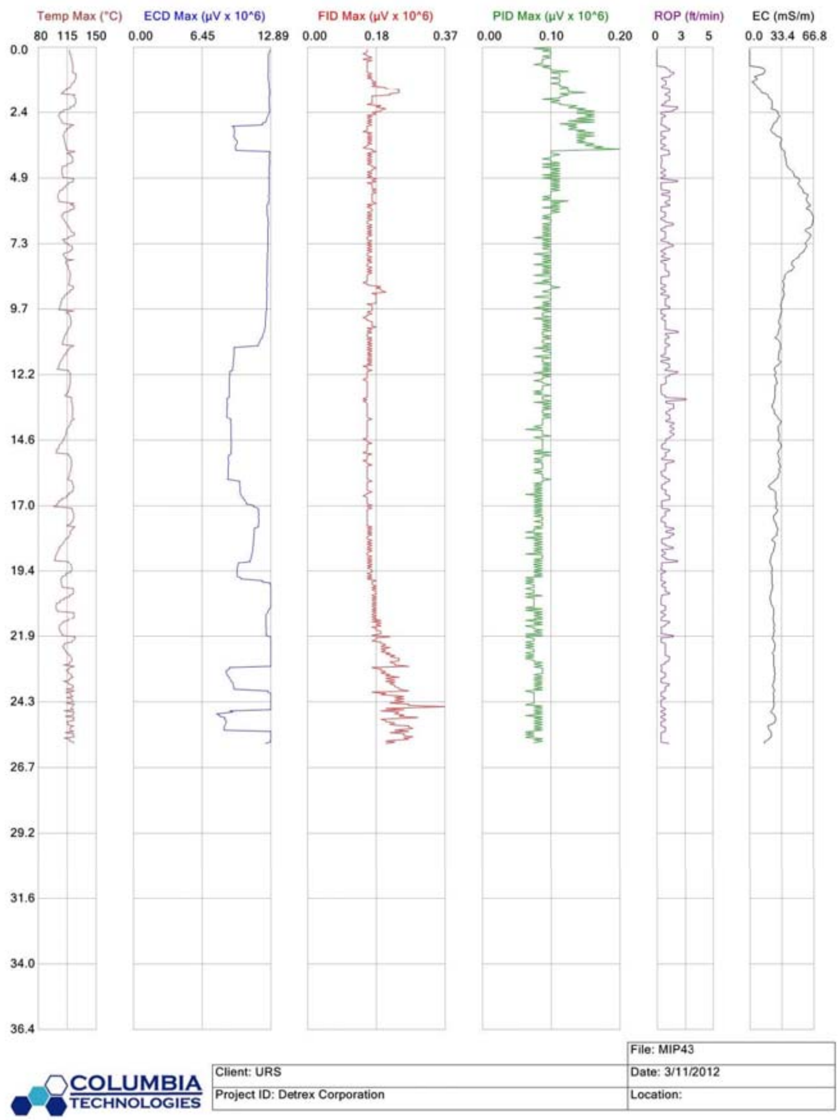
(south side, MW11S)

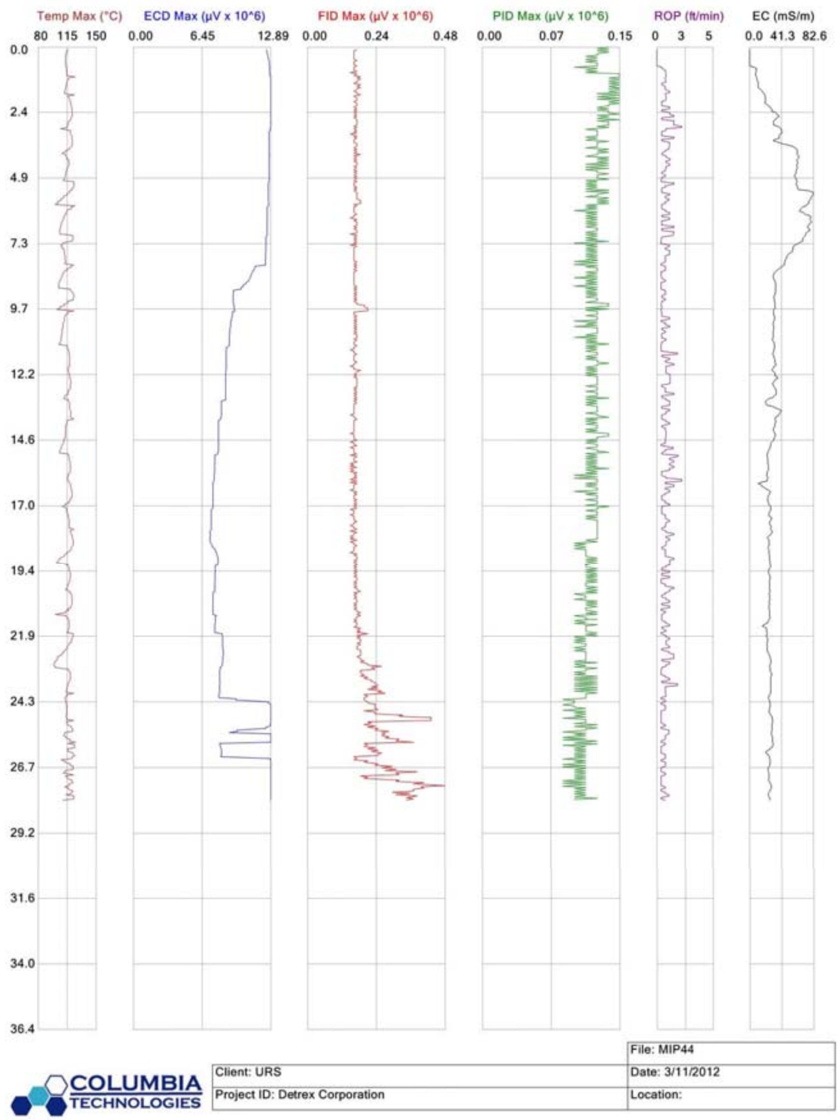
MIP – 42 Log

(south side, MW11S)



MIP – 43 Log
(south side, MW10S)





MIP – 44 Log

(south side, MW10S)

SOIL BORING OVERVIEW

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Soil Boring Overview

- Soil borings logged continuously, photographed, and inspected
  - Former Lagoon Area
    - GP-15: 0-20 ft, clay fill to 16.0 ft, DNAPL seep at 9.0 ft, sheen and DNAPL seeps at 19.0 ft
    - GP-24: 0-11 ft, natural clay soil, DNAPL seep at 10 ft
    - GP-30: 0-20 ft, natural clay soil, DNAPL sheen at 15-16 ft
  - Within Plant Area
    - GP-04: 0-16 ft, natural clay soil, DNAPL sheen at 10.0 – 10.5 ft
    - GP-26: 0-16 ft, natural clay soil, DNAPL sheen at 5.0 - 6.0 ft, DNAPL sheen at 8.0 – 9.0 ft
    - GP-29: 0-8 ft, clay fill to 3 ft, natural clay soil to 8 ft
  - Outside Plant Area
    - GP-34: 0-10 ft, natural clay soil, no sheen, vapor or DNAPL
  - DNAPL observed in thin, discontinuous voids / cracks and in water saturated silt lenses
  - Sheen observed in thin (1-2 ft thick), discontinuous, water saturated lenses within clay soil matrix

MIP Mapping

- Oblique View
  - 2 screening levels (33.5 x 10^6 and 25 x 10^6) max PID was 68 x 10^6 at MIP 36 (AST area)
- Overhead Mapping
  - 2 screening levels (33.5 x 10^6 and 25 x 10^6)
- Cross Sections
  - 2 North-South (Elevated PID at 5-15 ft and above 25 ft)
  - 1 East-West (Elevated PID above 25 ft, except lagoon area)

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Detrex Corp. Site – Ashtabula, OH

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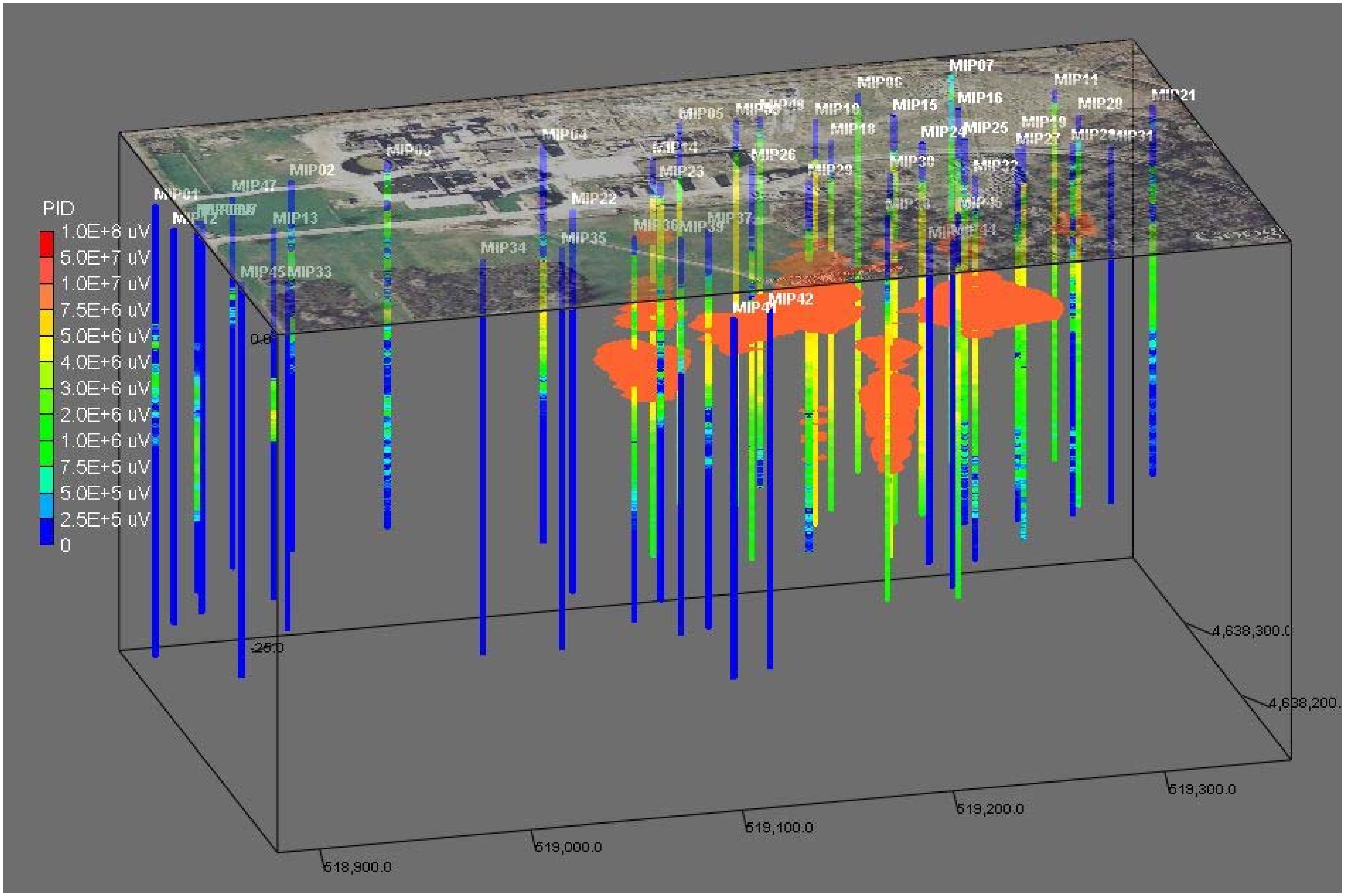
Oblique View 33.5e6



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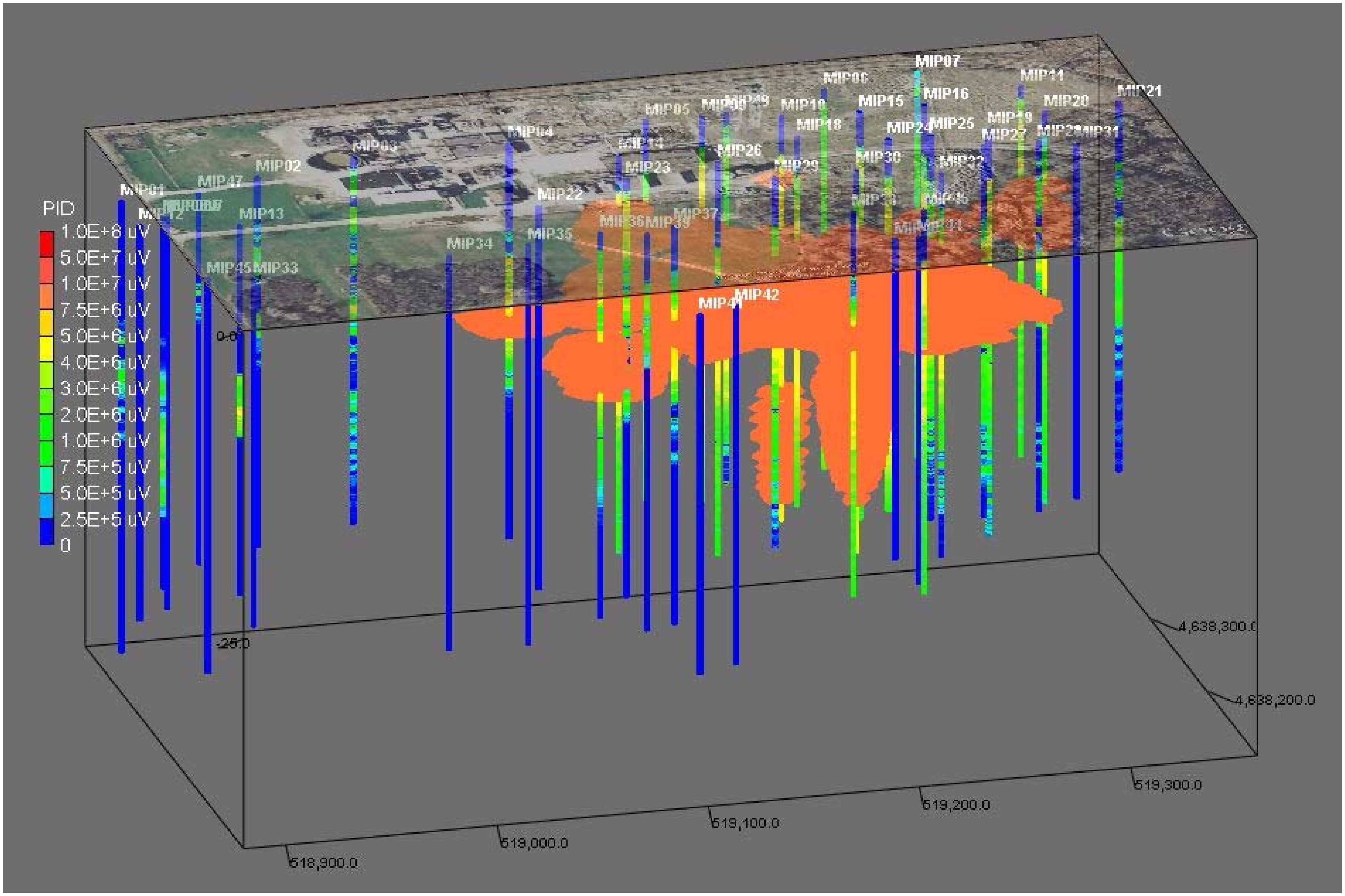
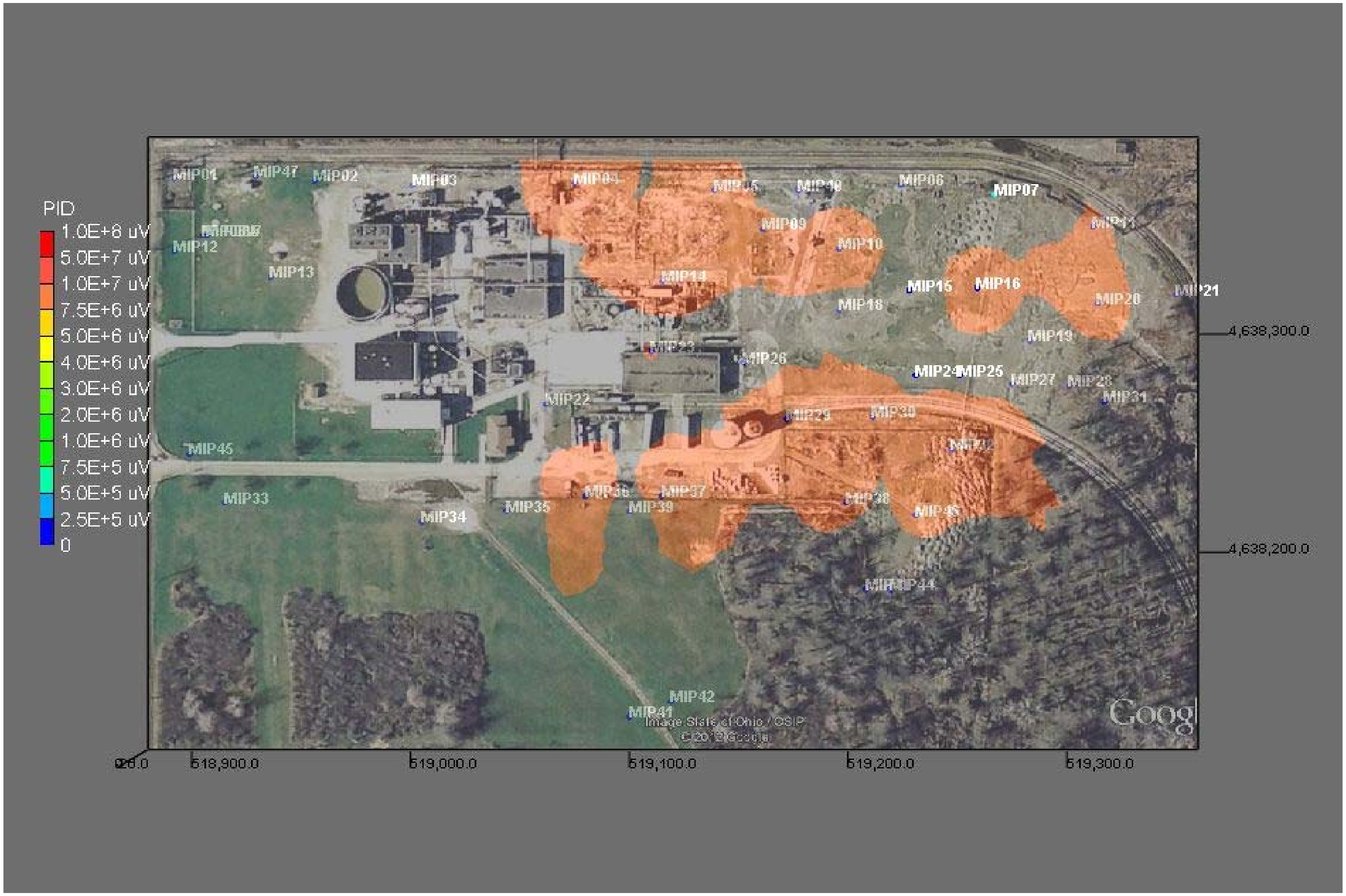
Plan View 33.5e6

Oblique View 25e6



Plan View 25e6



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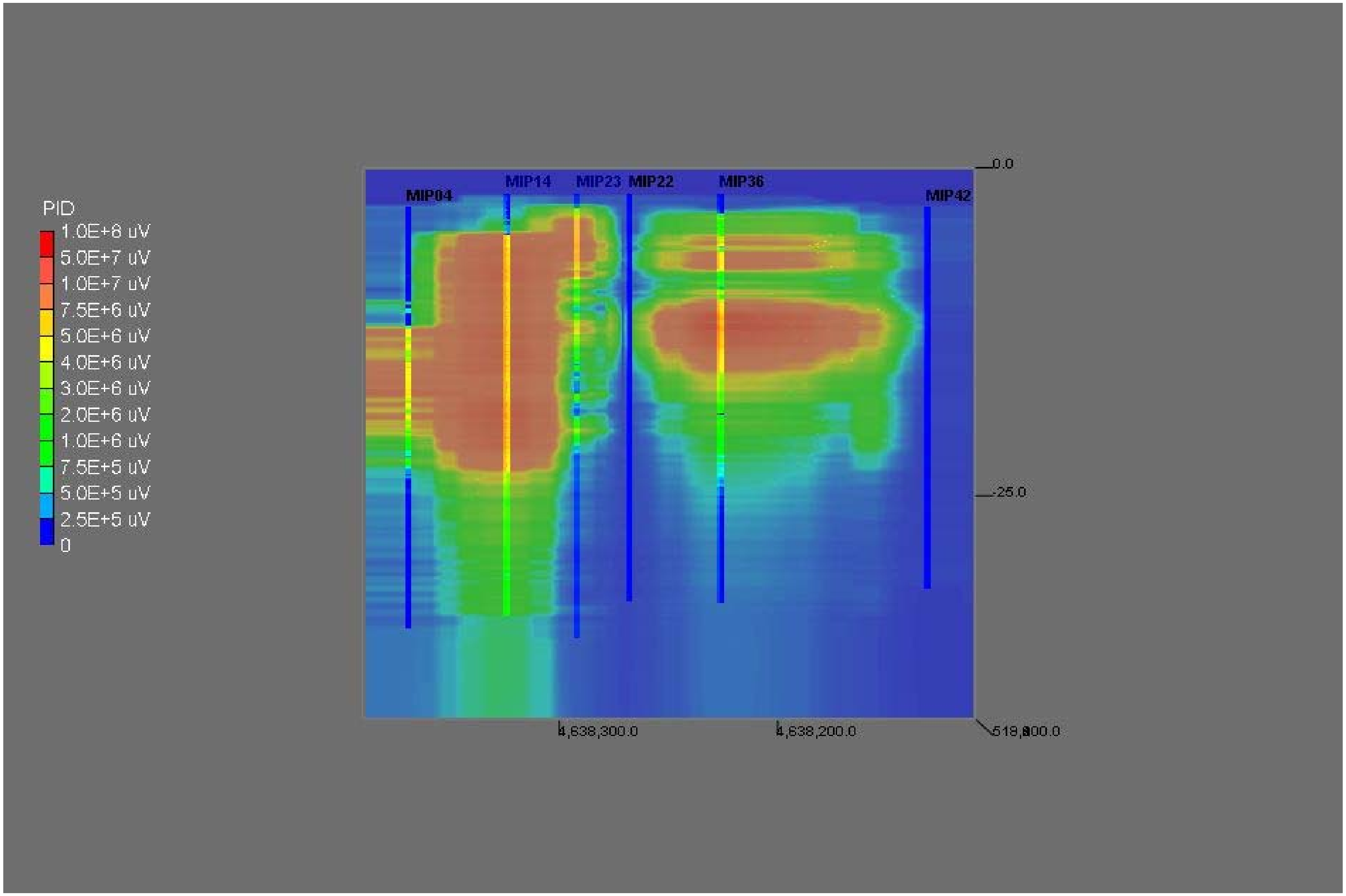
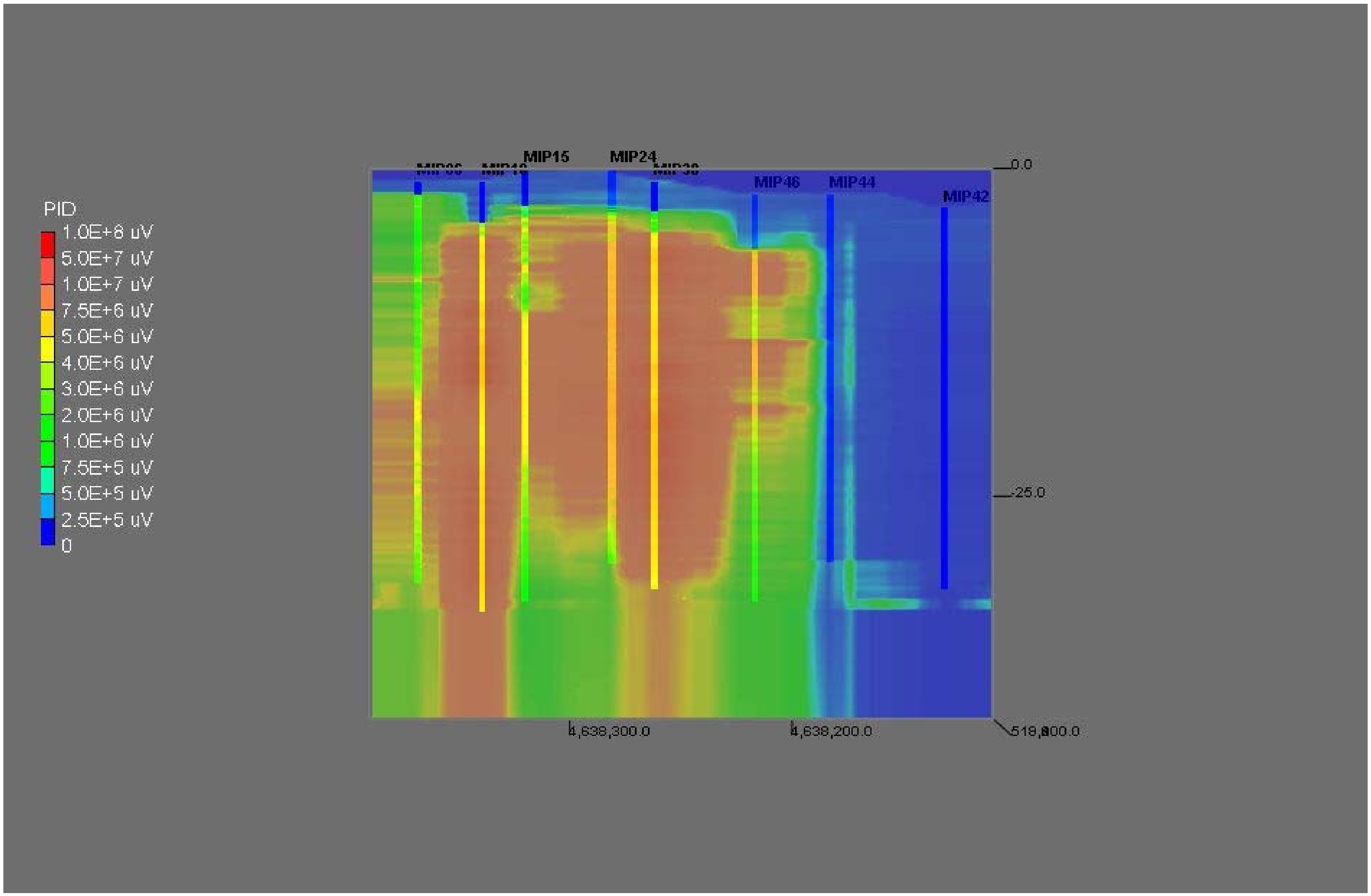
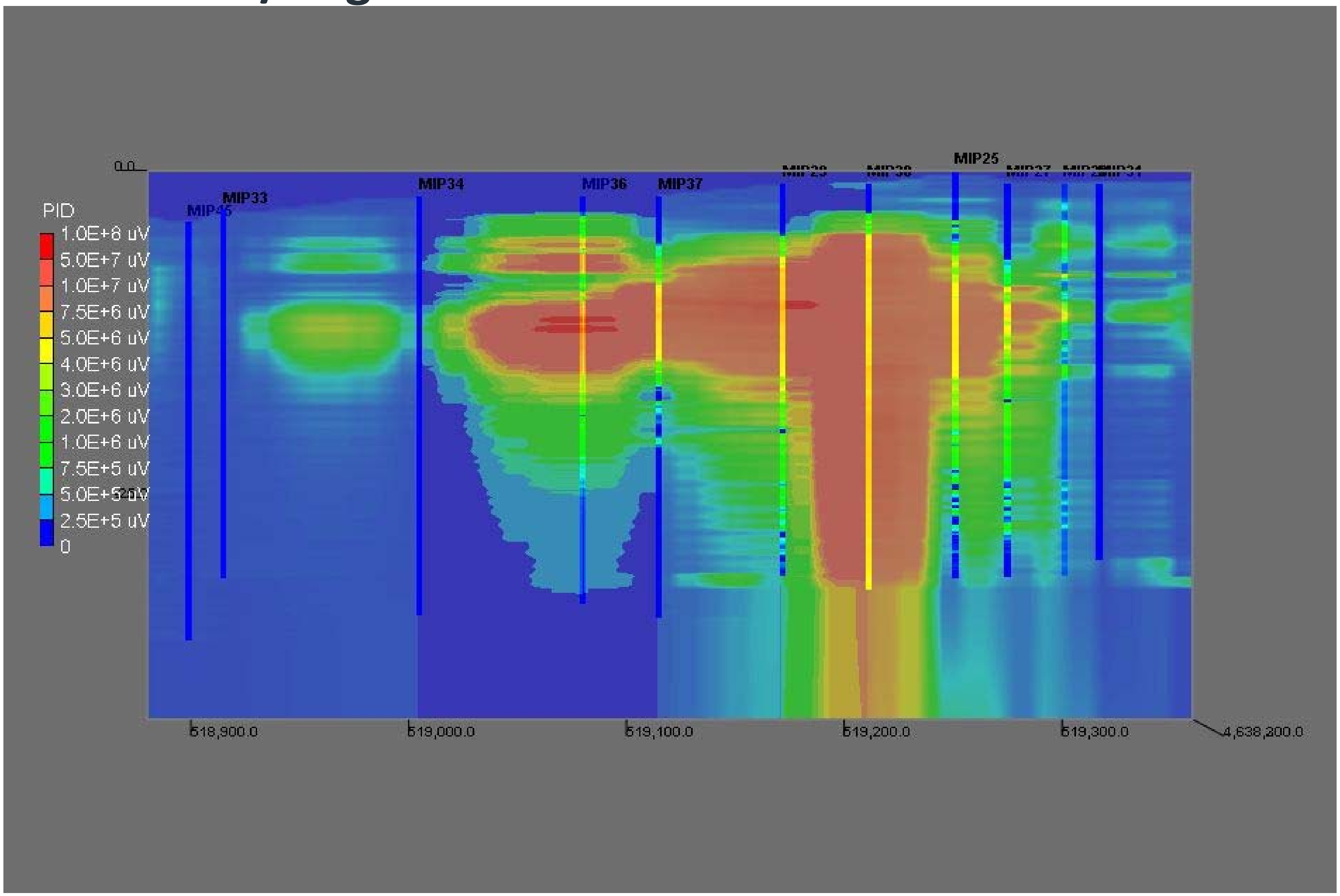
Cross Section -- North-South View 04-42 -- Plant Area



Cross Section -- North-South View 06-42 -- Lagoon Area



Cross Section -- West – East View 45-31 -- South Plant / Lagoon Area



UPDATED CONCEPTUAL SITE MODEL (CSM)

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Overview of Site Conceptual Model

- Lacustrine clay soils 0-15 ft (approx.) brown to gray, laminated
- Glacial Till 15-30 ft
- Lagoon area filled with clay soils to 15 feet, wet discontinuous silty-sandy lenses beneath
- Small, thin DNAPL seeps in discontinuous fill voids / cracks
- Perched water on top of till in thin, discontinuous sandy silty lenses
- Sheen observed in wet silty-sandy lenses
- DNAPL ganglia (small globules) observed in wet silty-sandy lenses in clay matrix

Overview of Site Conceptual Model

- Site soils are not aquifer material, and not capable of significant water yield
- Site soils are aquitard / aquiclude material

- For Example:
  - Aquifer materials have permeabilities that are generally > 10^{2} cm/sec and yield significant water.
  - Detrex site soils have permeabilities that range from 10^{-4} cm/sec to 10^{-8} cm/sec for lacustrine and till soils (H and V).
  - Designs for slurry wall installation require 1 x 10^{-8} cm/sec permeability for placement of bentonite barrier wall.

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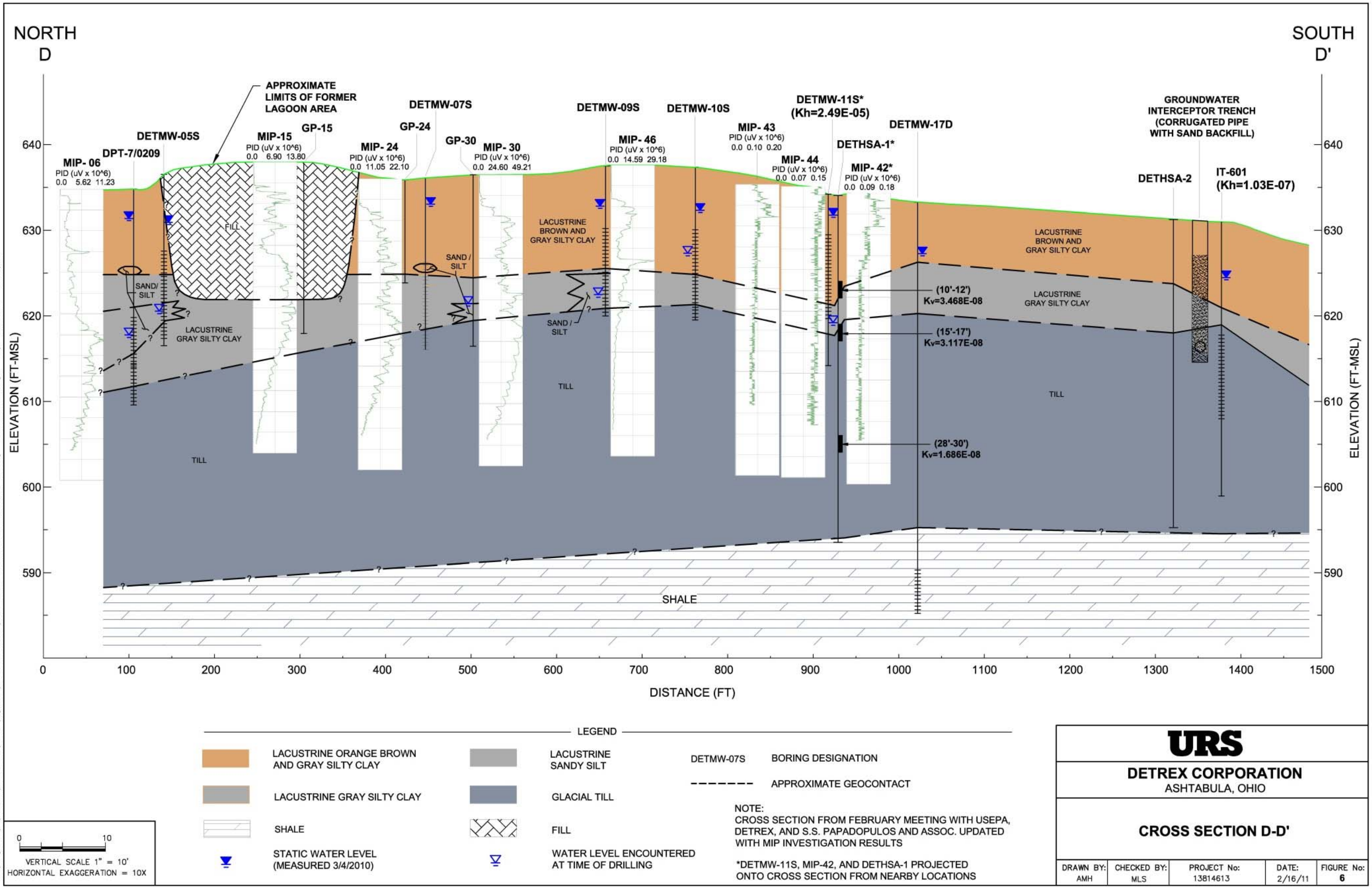

Overview of Site Conceptual Model

SUMMARY AND WORK PLAN DISCUSSION

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Summary of MIP / Soil Boring Investigation

- PID readings from MIP logs indicate a response to the following conditions
  - CVOC and SVOC impacted clay / silt soils
  - DNAPL sheen in thin discontinuous water saturated zones
  - DNAPL in voids / discontinuous cracks in backfill soils
  - DNAPL ganglia entrained in thin discontinuous water saturated zones within clay matrix

- Former Lagoon Area
  - Impact observed from 5 ft to 25 ft bgs
  - DNAPL seeps in voids / cracks in backfill soils
  - DNAPL ganglia in silty / sandy water saturated zones beneath lagoon bottom (i.e. below 20 ft)
  - Impact observed shallow (9-14 ft) east and south in natural clay soils (lacustrine) and in thin water saturated zones

Summary of MIP / Soil Boring Investigation – (con't)

- Inside Plant Area
  - Impact observed in shallower / thinner zones in natural soils: (i.e. 5-9 ft bgs, 12-15 ft bgs) correspond to wet silty/ sand lenses and top of glacial till
- Outside of Plant Area (West and South)
  - No impact southwest and south of lagoons / plant
  - Minor impact northwest of plant, near former outfall
- MIP Data indicate deeper impacted soil / water in lagoon area and shallower in plant area.
- MIP data indicate no horizontal migration of impacted material West, South (Fields Brook) and East.
- No significant, thick zones of DNAPL observed at any location
- When DNAPL observed in borings in plant / lagoon area found as:
  - Thin discontinuous cracks / voids in backfill clay soils
  - Sheen in wet silty / sand lenses
  - DNAPL ganglia in wet silty / sand layers

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Conclusions – Site Conceptual Model

- MIP data and 2012 soil borings verify previous reported site geologic conditions (i.e. low permeability lacustrine clay soils overlying low permeability glacial till deposits).

- No evidence of DNAPL or dissolved phase COCs migrating to Fields Brook from Detrex Site (i.e. 2005 test pits / borings; 2006 GWCT investigation; 2006 GWCT installation; and 2009 DNAPL investigation).

- Sheen and DNAPL ganglia occur in thin, water saturated silty / sandy lenses surrounding lagoons / plant areas north.

Conclusions – DNAPL Thickness

- Occurrence of > 4.0 ft of DNAPL in wells is not representative of DNAPL thickness in backfill / natural soils at Detrex Site.

- FBAG estimates of DNAPL volume (i.e. 680,000 gallons) are highly inaccurate and not based on DNAPL assessment technical guidance and literature.

- Exaggerated DNAPL thickness in site monitoring wells due to:
  - Monitoring well screens set partially below lower confining layer (i.e. DNAPL will drain into the well which acts as a sump).
  - During removal of water from a well, DNAPL may be drawn into the well by reduced hydrostatic pressure.

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Conclusions – DNAPL Thickness (con't)

- Published guidance indicates it is very difficult to construct a "true" DNAPL thickness well:
  - (Mercer and Cohen 1990) "DNAPL presence in wells should be evaluated in conjunction with evidence of DNAPL obtained during drilling."
- Well construction / completion influence elevation and thickness of DNAPL at the Detrex Site:
  - (USEPA 1994) "If the well screen extends below the top of a DNAPL barrier layer, a measured DNAPL pool thickness may exceed that in the formation by the length of the well below the barrier layer surface."
  - (Pankow and Cherry 1996) "The length of the DNAPL column in the well is rarely related to the thickness of the DNAPL pool in the aquifer. Only if the well is terminated at the base of the pool will the DNAPL thickness correspond to thickness in the aquifer."

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Conclusions – cont'd

achieved at the bottom of the pool. Figure 2.9.b shows the same situation, except that a few of the fractures are larger, which allow DNAPL entry into them. In Figure 2.9.c, all of the fractures are large enough for DNAPL entry, which is a less likely situation because it is probable that entry into the largest fractures and subsequent DNAPL flow in these fractures would limit build up of the pool heights, thereby preventing sufficient height to develop for entry into the smaller fractures. Given that fracture networks in aquitards are generally difficult to delineate, and that it is expected that not all fractures contain DNAPL, locating those particular fractures that contain DNAPL is very difficult.

Figure 2.10 shows four scenarios in which DNAPL enters into, and in some cases travels through, an aquitard. In Figure 2.10.a, the fractures do not penetrate to the bottom of the aquitard and therefore the aquitard protects the aquifer from actual DNAPL entry. Figures 2.10.b and 2.10.c show aquitards that have a few fractures that extend to the bottom of the aquitard, providing pathways for DNAPL entry to the underlying aquifers. In Figure 2.10.d, the DNAPL pathway through the aquitard is a stratigraphic window rather than fractures. At some sites, it is not possible to discern from the available field

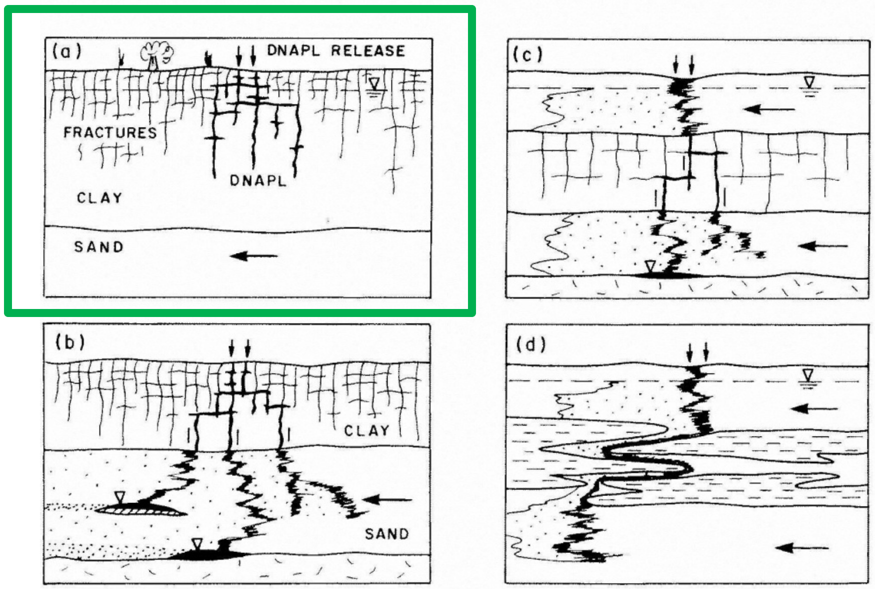

Figure 2.10 Conceptual scenarios for DNAPL movement through clayey aquitards: a) partial penetration because open fractures do not extend to the bottom of the clay deposits; b) penetration through a few deep fractures causes DNAPL accumulation in the underlying aquifer; c) penetration through fractures in an aquitard between two sand aquifers; and d) a stratigraphic window in the aquitard provides a pathway for DNAPL flow.

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Detrex Corp. Site – Ashtabula, OH

13.3.2 Observations in Wells

At some sites, DNAPL can be found in one or more monitoring or pump-and-treat wells. Although this finding confirms that the site is a DNAPL site, it is generally impossible to relate the thickness of DNAPL in such wells to the volume of DNAPL in the subsurface. In addition, it is generally not possible relate the finding of DNAPL in wells to the vertical distribution of DNAPL in the subsurface. The only circumstance in which it might be possible to relate DNAPL thickness in wells to the thickness of DNAPL pools in the subsurface is when DNAPL occurs in large discrete pools in granular media. This has been found at some creosote and coal tar sites where very large volumes of product have been released to the subsurface, but it is rare for chlorinated solvent DNAPL sites. Even when large pools of solvent are found, wells must be installed precisely to intersect the entire vertical thickness of the pool. If the wells do not extend to the full thickness of the pool, the observed DNAPL thickness will be erroneously small. If the wells extend deeper than the base of the pool, the observed DNAPL thickness will be erroneously large. And, even when wells are installed appropriately within the pool, the DNAPL thickness in the well can only be related to the pool thickness through the use of information on the capillary properties of the formation and of the well material, together with the properties of the DNAPL. This type of information is seldom available.

Of course, if DNAPL free product has not been detected in wells, it cannot be concluded that DNAPL is not present in the aquifer. At many sites, the zones of free-product DNAPL may be very small in areal extent relative to the spacings of borings. Consequently, the DNAPL zones may be intersected only infrequently by borings. Even when DNAPL zones are intersected, there are numerous circumstances in which the DNAPL may not be found in the well. For example, a DNAPL zone may be thin in vertical extent, and may not contact the open interval of a monitoring well which passes through it. Also, most of the DNAPL in the subsurface may be present only at residual saturation, and such DNAPL will not be able to enter the boring or monitoring well.

Figure 13.8 illustrates several circumstances that will inhibit identification of the presence and distribution of a DNAPL using monitoring well observations. In most circumstances, the sand pack or filter pack material used in well construction is more permeable than the geologic media and should allow unrestricted entry of DNAPL into the well bore. However, DNAPL will always migrate along the most permeable pathways, and will commonly accumulate in relatively permeable zones that are bounded by lower permeability zones. If DNAPL occurs in thin layers or pools, there may not be sufficient fluid potential in the DNAPL to overcome the capillary resistance of the sand pack and allow entry into the boring (see Figure 13.8.a). To minimize this possibility, sand pack material can be sized to promote DNAPL entry.

DNAPL layers and pools are generally thin compared to the open interval of a boring, and may not be identified during drilling operations. If DNAPL enters a boring, it will sink to the bottom (see Figure 13.8.b). If the DNAPL accumulation is sufficiently large, it will enter the well screen and may be found by well sounding or sampling. However, it will not be possible to relate the elevation of the DNAPL in the monitoring well to the elevation of DNAPL zones in the formation because DNAPL could have entered anywhere along the open interval of the boring.

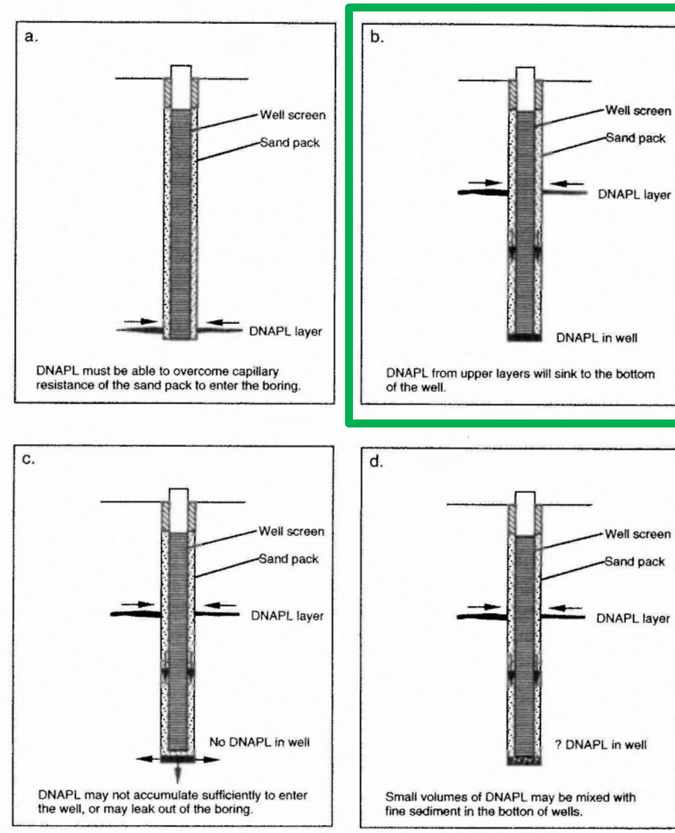

Figure 13.8 Various conditions required for the accumulation and identification of DNAPL in a monitoring well.

DNAPL that enters the boring and sinks to the bottom will not enter the well screen unless the DNAPL accumulates as high as the bottom of the well screen. Monitoring wells are commonly constructed so that the well screen is some distance above the bottom of the sand pack. If the volume of DNAPL that enters a boring is small, it may not be sufficient to rise up to the well screen. If the formation surrounding the bottom of the boring is relatively permeable, it is also possible that the DNAPL may exit the boring before it can accumulate sufficiently to enter the well screen (see Figure 13.8.c). In this case, not only will the DNAPL go unidentified in the monitoring well, but the boring will become a conduit for DNAPL migration deeper into the subsurface. Niemeyer *et al.*

Conclusions – Distribution of COCs

- DNAPL is not migrating to Fields Brook from Source Area (MIP confirms previous findings reported to USEPA from 2005-2010).
- Impacted groundwater is not migrating to Fields Brook from Source Area (No dissolved phase constituent plume identified south of former lagoon area, which is typical of migrating plumes).
- No thick / extensive zones of DNAPL observed in backfill / natural soil anywhere on site.
- DNAPL, when observed, occurs in discontinuous voids / cracks in backfill and wet silty / sandy lenses.
- Sheen and DNAPL ganglia occur in thin, discontinuous, water saturated silty / sandy lenses in clay matrix surrounding lagoons / plant area.

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Conclusions – cont'd

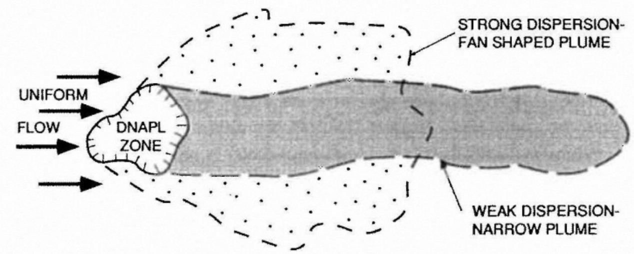

Figure 2.11 Influence of hydrodynamic dispersion on plumes from a DNAPL source zone in a sand or gravel aquifer with uniform steady flow. The plume is long and narrow for the weak dispersion case, and fan-shaped for the strong dispersion case.

organic or inorganic. Studies of dispersion in numerous sand and gravel aquifers the 1980s showed that, almost without exception, dispersion is weak, particularly the directions transverse to groundwater flow. In the fan-shaped plume of Figure 2.1 transverse and longitudinal dispersion causes considerable decline in concentration the plume spreads in the aquifer with groundwater flow. In the narrow plume, on tl other hand, rate of concentration decline with distance in the direction of flow is muc smaller.

The type of nearly uniform plume width found in Figure 2.11 is expected in aquife where the groundwater flow is relatively uniform, devoid of diverging or convergir flowpaths. Because dispersion is typically weak, many solvent plumes emanating fro DNAPL source zones exhibit high concentrations far from the source zone. And, sinc the maximum contaminant levels (MCLs) specified in drinking water standards are ve low, concentrations far from the source can be much above these MCLs. Although plun concentrations for chlorinated solvents and other DNAPLs are large relative to drinkir water standards, they are not large enough to cause the plumes to **sink** due to densi of the aqueous solution. Density is an important factor at DNAPL sites, but only wi respect to movement of the DNAPL and not the migration of plumes.

The shape and size of a source zone has a strong influence on plume dimension Thus, although many solvent plumes in granular aquifers are long and narrow, mar others are wide because their DNAPL source zones are wide. The details of the distrib tion of DNAPL residual and accumulation zones below the water table are rarely know However, at most sites, it is expected that they are complex due to geologic heterogenei and variable DNAPL releases. Downgradient of such DNAPL source zones, weak di persion allows the distribution of dissolved concentrations to be highly variable spatiall particularly close to the source zone. Farther downgradient, dispersion causes variabili of the concentration profiles to diminish. Figure 2.12 shows a schematic example of th dispersion effect. The actual distance at which the concentration profiles become le irregular depends on site conditions.

Little is known about dispersion in fractured geologic media. Although there a many large contaminant plumes in fractured-rock aquifers, none has been monitored

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Conclusions – DNAPL Recovery

- Occurrence of DNAPL is discontinuous, cracks / voids at shallow depths (10-15 ft) suggests the design proposed by FBAG will not be useful for DNAPL / groundwater drawdown.
- Low permeability soils (i.e. range from 10^{-4} to 10^{-8} cm/sec) will result in low / limited groundwater flow to recovery wells, if installed.
- Lack of thick, continuous layers of DNAPL observed at the Detrex Site indicate previous volumes by FBAG are erroneous and cannot be substantiated using site data (i.e. 680,000 gallons vs. likely one order of magnitude less).
- Site Remediation Objectives and Recovery of DNAPL at the Detrex Site needs to be re-evaluated per ESD considering USEPA requirements for testing well designs.
- Limited DNAPL occurrence in shallow silty / clays and in thin discontinuous lenses indicates vertical wells to 30 ft are not appropriate for recovery.

PATH FORWARD

Path Forward

- Onsite Technical DNAPL Occurrence Demonstration April – May 2012 (Geoprobes in lagoon area / plant area)
- Revise Work Plan with MIP / Soil Boring Results / USEPA comments received 2/29/12
- Revisions to include:
  - Eliminate Recovery Well Testing Plan
  - MW / PZ Inspections (partially complete)
  - Initial DNAPL Recovery Testing (select specific wells I.e. DETMW 05, 06, 07, 08, 09 and 10)
  - Data Evaluation
  - Site Conceptual Model Update
  - Technical Meeting with URS/Detrex (Discuss Recovery Well objectives and function considering MIP findings / observations of DNAPL along with technical alternatives for DNAPL recovery)

Q & A